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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 900 men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are SIX dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for ASSOCIATE membership is TEN dollars, and the annual dues TWENTY dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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SANITARY PROTECTION OF PUBLIC WATER SUPPLIES.

BY ALLEN HAZEN.*

I am going to speak to you to-day about the relations between water supply and disease, and about what is done and may be reasonably done to keep public water supplies from carrying disease, and from ever being in a position where those who take the water may have well-grounded anxieties as to the safety of the supply.

I propose to discuss this matter in very general terms, and with particular reference to the developments of the last years, that have put at our disposal new and most useful methods of control.

The progress that has been made has been so great that there are now few public water supplies in American cities that ordinarily cause disease among those who use them. The improvement in this respect as compared with conditions of thirty years ago is very marked. Conditions that were common and that were regarded with indifference in 1890 would be intolerable in 1921.

The question now presented is not so much how to keep our water supplies free from disease-producing qualities, for that question has been answered; but rather to see what precautions may best be taken to secure safety without duplicating to an unreasonable extent parallel lines of defense when this involves added cost and an unreasonable burden on the people who pay the bills.

The question is to be taken up primarily from the standpoint of surface supplies. Such supplies from rivers, lakes, ponds, and artificial reservoirs constitute a large part of the public water-supply systems of New England.

It is unnecessary to even mention to you at this time the ways in which these waters become polluted; and the reasons for preventing or removing the effects of the pollution. Our late president, W. T. Sedgwick, contributed greatly to the knowledge of these matters, and you are all familiar with them.

The general satisfactory conditions of public water supplies to-day may be largely attributed to the fact that knowledge of these matters is so

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generally distributed that there are men in practically every community who know where the danger lies and are on the lookout for it.

The principal methods of protecting these supplies, and those who use the water, from the effects of injurious pollution may be briefly enumerated.

1. Ownership of Catchment Areas.

Ownership permits trespassers to be excluded, and theoretically gives complete protection. But we well know from practical experience that even ownership does not quite accomplish this result. Trespassers do get on the land and at the water. Even the water-works people themselves, including necessary inspectors, and the men who must be sent upon the ground to plant the forests and to cut the old trees and to repair fences, may sometimes be careless; and their presence represents some danger to the water supply. If the catchment area is large, roads and even railroads must be permitted to cross it, and in every case something of full efficiency is lost. The ownership of land to control the quality of the water supplies is very general in American water-works systems. It is more often partial than complete. Parts of catchment areas from which pollution is particularly feared have been purchased. Often those parts that could be purchased have been bought and other parts remain in private ownership. Ownership of land is a useful method. Sometimes it is indispensable. Frequently it is costly.

2. Sanitary Supervision of Those Who Live on Catchment Areas.

This applies to areas that are not owned by the water works. Some supervision is attempted in nearly all cases, except where the catchment area is very large. Leading is better and more effective than driving; and a kindly-disposed sanitary inspector authorized to do various things at the expense of his employers gets along with residents and cleans up bad conditions where legal pressure, under drastic laws, is slow and expensive and frequently fails in the desired results. A great deal of good is accomplished by sanitary supervision of rural populations upon catchment areas from which domestic water supplies are drawn; and a considerable part of the danger that would otherwise exist because of such populations can be, and actually is, removed in this way.

3. Treatment of Sewage from Towns upon Catchment Areas.

Such treatments of sewage are carried out by or for the towns and villages upon areas tributary to the water supplies of Boston, New York, and other cities. In the case of the Boston supplies it is fortunately possible, in most instances, to take the treated sewage out of the catchment areas; and in this case the protection is more complete than it otherwise would be. In other cases this cannot be done.

It would be a happy condition if catchment areas could be always found where such sewage treatments were unnecessary; but there are many cases where this is not possible, and the best must be made of conditions as they exist. Fortunately, experience and observation extending over many years show that these matters can be managed, especially when the quantities are not too large and all other conditions are favorable, so that the risks to the water supply are greatly reduced.

4. Purification of Water by Natural Agencies.

This related especially to that which occurs when water is stored in a large reservoir. The disease-producing qualities of water, represented mainly by bacteria, are not usually long-lived; and when water is detained for months, or even for weeks, the risk of its serving as an agent of transmission is reduced. The purification of water by storage in this way has been an important element in maintaining the excellent sanitary quality of many supplies. It has its weak points, but notwithstanding them it has been one of the most useful methods in checking the spread of water-carried disease. The dangers in connection with it are, first, short-circuiting, meaning thereby the flow of polluted water through the reservoir to the point from which water is taken by a direct course and in a short time, while the bulk of the water in the reservoir remains outside the current of flow; and, second, the loss of action at the time of refilling after the reservoir has been emptied, or nearly emptied. Reservoirs are constructed primarily to maintain the volume of supply; and to serve their function fully in this respect the water must be used, and the reservoir emptied when there is occasion for it. After this happens, the reservoir is again filled with water that frequently comes in with a rush following a rain at the end of a dry period. At such times the protective action of storage is temporarily destroyed. In a few cases — such, for example, as that of the Wachusett Reservoir — the reservoir has been deliberately built larger than otherwise necessary, so that it would never be necessary to empty it, for the purpose of affording additional opportunities for purification by storage.

5. Filtration.

Without going into particulars, I shall include under this head, coagulation and all the other chemical treatments that are sometimes used in connection with it, and the basin treatments that precede it. By filtration of water, impurities are removed more or less completely. Some impurities are removed completely, others in part only. The bacteria, that must be removed to stop the disease-producing properties, are very small in size. To stop them completely requires either an exceedingly fine strainer, such as a Pasteur filter, or a sand filter of the very best construction, or else a well-adjusted chemical treatment that serves to tie up and entangle the little

bodies and make their removal in the sand easier and more complete. Looking to standards that were common some years ago, filters could be counted on to remove 95, 98, and even 99 and in some cases 99.9 per cent. of the bacteria of the applied water. The varying percentages depended in part upon the competence and adequacy of the plant and upon the skill used in its operation; and in part upon the quality of the water. Some waters are more easily treated than others, and higher bacterial efficiency is obtained from them, other conditions being equal.

In the last years there has been an undoubted tendency to cheapen filtration processes at the expense of their efficiency, and to depend in greater measure on other lines of defense.

6. Disinfection.

By this is meant the application to the water of a substance which acts as a poison to bacteria and destroys them, even when applied in such minute quantities that it is not injurious to the people who drink the water. There are other disinfectants, but at present chlorine is the only one that requires consideration. Disinfection is the most recent of the major processes of water protection now in use. It first came into use in the United States about 1906. The first disinfecting material was hypochlorite of lime. Chlorine began to be used a few years later, and proved to be better.

Under some conditions chlorine can be used so as to almost entirely kill the bacteria of the water; but there are other conditions under which the action is less complete. If the water carries organic matter, chlorine may be absorbed by it before the bacteria are reached. The dose must be carefully adjusted to cover the needs of the organic matter of the water treated and to leave a surplus sufficient to dispose of the bacteria. On the other hand, this surplus must not be so large as to be too troublesome by imparting tastes and odors to the water. If chlorine is applied to water that has not been filtered, there may be masses of organic matter which shelter bacteria in their interiors and protect them from the action of the chlorine during the short period during which there is an effective amount of chlorine in the water. Some colored river waters have been found to require very large doses of chlorine for their disinfection, and it is not impossible that the organic matter in them in a colloidal condition may sometimes play an important part in protecting bacteria from the action of the chlorine.

Having now briefly mentioned the major agencies by which water is protected or freed from disease-producing qualities we may consider their application to public water supplies.

If one line of defense is 100 per cent. perfect and can be always depended on, we might concentrate on that in a particular case. If it were fully sufficient all the other agencies might be abandoned and the water would be safe. But no one of these lines of defense is so perfect and so free

from danger of interruption and of irregularities in operation that we can afford to tie up to it to the neglect of all others.

Full safety is only secured by the use of several lines of defense. There are so many variations in conditions and in the possibilities of water supplies that generalizations may not be wisely undertaken. In each case the possibilities of protection must be considered, and lines of protection arranged to supplement each other and work together to produce a degree of protection and safety that is sufficient.

We must not go to unreasonable extremes. Human lives are valuable and must be carefully protected, but it is not to be reasonably expected that water supplies will be built that will never transmit any case of disease. To expect that is as unreasonable as to expect that railroads will be built and operated so that there will be no accidents. The underlying basis of what it is really worth while to do is much the same way in both of these cases. Risks may be estimated and values assigned to them, and the works required to eliminate and reduce these risks must not be unreasonably costly in comparison with the fair estimated values of the risks that they replace.

This may seem a cold-blooded way of considering a matter of public health; but is it not a sound, sensible way? And is it not the only way that will stand the test of final analysis? In deciding what lines of protection are to be used, and how far each is to be used, do we not have to compare the cost of applying each with the reduction in risk to human life that is eliminated by its use, and see whether it is worth while?

In discussions of the matter it may not always be wise to state the proposition bluntly. We may simply say in our reports that such and such a risk is too small to require consideration in a certain case. But this is only a general statement. If it is good for anything it must rest upon some comparison of the risk and its value with the cost of the works needed to eliminate or at least to reduce it.

As a matter of engineering, we usually have the choice of several methods of defense. To use all of them to the fullest extent would be to do more than the business warrants. It would be piling up costs against the water takers, beyond the point where all appreciable risk has been eliminated. As we do not need to use all the lines of defense to the limit, how shall the selection be made?

This will need careful study. We need to know how to select those lines of defense that will give us the desired security with the least cost and with the least disturbance to existing desirable conditions. Often the answer will be found in the application of several lines of defense. For instance, taking the first one enumerated above — it will be worth while to buy and control, as completely as ownership gives control, certain parts of the catchment area. These parts will naturally be the areas along the streams and near the intakes and above the reservoirs. They may also extend to areas which, because of topography and other conditions, are

more than unusually favorable for future occupation and pollution. The cost of the land must be considered. It will be worth while to buy large areas of cheap wild land. It will not be worth while to buy highly developed property that has been arranged to prevent pollution. A great deal of protection may be secured by ownership, even though only a fraction of the whole catchment area is acquired.

With the aid of other lines of defense, and with sanitary supervision, it may be possible to draw safe water from catchment areas on which farming, grazing, and forestry and other enterprises are conducted. The use of catchment areas for park purposes and as a recreation ground for summer visitors may also be considered. There are some extra difficulties, because occupants of this class may be harder to keep in order than permanent inhabitants. Still the advantages of such double use of mountain areas are very great; and, if other lines of defense are well developed, there is no valid reason why this should not be done.

The storage in large reservoirs often or usually helps in maintaining the safety of the supply, but it is not to be depended upon at all times. It fails to be reliable when heavy rains follow droughts that have depleted the reservoir. It has been one of the great elements in maintaining the sanitary quality of some of our supplies, even though it is not efficient at all times.

The progress that has been made in the last decades in filtration and disinfection has been so great that the idea has sometimes been expressed that with such treatments it is no longer necessary to keep up other lines of defense. It has been thought by some that it was unnecessary to purchase lands on catchment areas for protective purposes, and that it would even be possible with the filtration of the water to seal great areas of such lands previously purchased. It has been suggested by others that sanitary supervision of the population on catchment areas could be reduced or eliminated when the water was filtered. Such ideas can hardly be accepted as representing sound judgment. The protection afforded by filtration and disinfection may be made very complete; but new discoveries are constantly being made, and new points of view are reached as more is known. The importance of each new advance is apt to be exaggerated at the time. Subsequent experience often shows unexpected drawbacks. We do not even know about all of the disease-producing qualities in water well enough to be sure that all of them are eliminated with the bacteria that we count, and on which present judgments of the efficiency of the processes are mainly based.

The test of filtration by laboratory methods may seem wonderfully complete and but little short of the ideal, but actual experience through a term of years brings into play other influences that must not be forgotten. Unusual conditions when the water is more difficult to treat occur perhaps only at long intervals. There are difficulties at certain temperatures, coming each year. The purification of water at the freezing point and at

summer heat are quite different matters. Then there is the human element; success in operating depends upon unrelenting vigilance as well as upon skill. Accidents will sometimes happen to locomotive engineers; and accidents will sometimes happen to filter operators, and to the men who regulate the chlorine. These things must be given their due weight in considering the whole problem. Not an unreasonable weight, to be sure, but they must be judged in the light of broad practical experience.

As the chlorine kills nearly all the bacteria, we may logically let up on the rigidity of our filter requirements; but how much? Can we put the filter back to the point where it is only a rough strainer? Or is it not wiser to keep, even at added cost, the major part of the splendid efficiency that was obtained by the best filters before chlorine was used? And with these processes of filtration and disinfection in use is it not wise to retain to the full ordinary limit the sanitary supervision of rural populations developed before disinfection began? This is usually an inexpensive part of the protection, and it certainly produces results in the safety of the furnished water supply.

The question of the ownership of the land is a difficult one. There has been much discussion of it. Divergent views have been held and warmly advocated. Some cities, especially in the west, have been ambitious to own their entire catchment areas, and a few have come very near to realizing this ideal. In the East the difficulties of large ownership are greater, but there are few eastern cities using impounding supplies that have not made serious efforts to control at least the points of greatest danger. Looking at it broadly this has certainly been a wise policy. It may seem less necessary, now that filtration is so generally used and chlorine applied, but it is certainly in the line of safety.

Then there are the supplies — not very numerous, to be sure, but there are very important examples — where the sanitary quality reached by the lines of defense already in use has been so high that it has not been thought necessary to use chlorine. Some of us think, even in these cases, that the use of chlorine as insurance against remote contingencies would be worth while, but we must admit that results actually obtained without it leave little ground for criticism.

In these cases, with no chlorine, there is not risk of the tastes and odors that so often follow its use, and there is also a pride in having a water of so good a quality that it does not need disinfectant to improve it.

The standards of quality of public water supplies have increased, and will no doubt increase still further. When water that caused only a few deaths replaced water that caused a great many deaths, the improvement was so great that it seemed at first to be wholly satisfactory. As years go by, and our students and laboratory men study the cases minutely and find out what is happening, they sometimes find that conditions might be still better. Standards are again raised, and still better water is demanded. The art of water purification has advanced in the last decades to meet these

demands. How far it has yet to go and how the best-informed sanitarians of the future will regard the qualities of water now supplied can only be disclosed by the future. It is certain that polluted waters of years ago produced more disease and more deaths than can be accounted for by present theories of water-carried disease. When we have stopped the bacteria that are counted in the laboratory, have we stopped all the disease-producing qualities of the water? That is what we do not yet fully know, and until that question is answered more conclusively than there seems to be an immediate prospect of its being answered, we shall do well, within reason, to stick to all the approved lines of defense that are in use, and that can be economically maintained without going to unreasonable extremes.

In the meantime there is much to be done. Information is ahead of practice. There are opportunities in New England and throughout the country to secure added safety by the better application of well-known methods; and it is for us to see that no promising opportunity is lost.

Discussion.

Mr. Frank W. Green.* There are three minor lines of defense that Mr. Hazen did not touch upon, which in our case are becoming of considerable importance. These are typhoid innoculation of the inhabitants of the watershed, proper handling of typhoid patients, and the establishment of swimming pools by the cities, on or adjacent to watersheds.

Typhoid Innoculation. Every one should be immunized against typhoid fever. During the war millions of soldiers were innoculated, and the results warrant us in making it universal. The period of immunization will probably increase, as in small-pox vaccination, until those that have been caught young will require but one or two treatments to last a lifetime. In some countries typhoid fever is so infrequent of occurrence that young medical students have difficulty in finding cases for study. There is no reason why this disease of filth and carelessness cannot be banished from our country. Are we doing our whole duty in this matter?

Handling of Typhoid Patients. Doctors and nurses should be held responsible for secondary cases occurring from patients under their charge, and cases occurring on a watershed should be removed to a less hazardous locality. We heard this morning about the typhoid epidemic at Salem, Ohio, which was directly due to a single case being so carelessly handled that the entire water supply became infected. These people had undoubtedly been drinking their own sewage for years without ill effects, but as soon as unsterilized sewage from a typhoid patient entered their water supply, a very severe epidemic developed.

*Superintendent, Filtration, Montclair Water Company.

Swimming Pools. Bathing has become very popular, the last few years, and some cities have established natatoriums so that their inhabitants may have proper facilities for indulging in this most healthful sport. Others are not so decent, and the younger residents, at least, will bathe in any pool or river that they may find, irrespective of what subsequent use this water may be put to. Notices and watchmen are of little avail on a large watershed. Many will use a river for bathing even when they know that they are to drink the same water, and as a matter of fact it does not appear to affect the bacterial quality of a supply to have even large numbers of people use it for a swimming pool, so long as they are not typhoid "carriers." From an esthetic standpoint it is very undesirable to have a supply used in this manner.

Mr. A. Prescott Folwell.* There is another source of danger of typhoid, that is growing more important, and while it is not, perhaps, of direct concern to the water-works men, in a way it may directly appeal to them, — and that is what we may call "touring typhoid."

During the last two or three years a large percentage of the population of the country has taken to spending frequent vacations in touring the country in automobiles, and a great many of them, especially in the middle West and far West, spend a large percentage of their nights sleeping out rather than in hotels.

At first each person or each party camped where they could find a convenient and inviting spot, but as time passes, and quite rapidly in fact, certain spots are becoming popular, and you will find in many of them one or more camping parties almost every night during the camping season.

Now, a great many of these are absolutely in no proper condition as to either the water the parties drink or the sanitary arrangements that they make at their temporary, one-night stands. It seems to me that some control of this matter ought to be instituted. It hardly seems possible that the city authorities (or, as most of these camping places are outside of the city limits, we will say the state authorities) can take the pains to make frequent inspections of all these places. They may not be directly interested in conditions at such places, but indirectly they are, because typhoid contracted through carelessness of these people in the country is of course brought back to the city when the tourists return to their regular homes.

In the West a great many cities have established camping places within or near their borders, put up signs, and established both sanitary conveniences and cooking conveniences, places for throwing lunch boxes, banana skins, and one thing and another, and also have extended a line of small pipe from their water-supply system to furnish pure water to these campers. In that way it seems to me it may directly concern some of the water-supply people, and if they have near their cities such places frequented by campers, I wonder whether it would not be worth while, in the interest of the citizens themselves, to carry pipe lines out there and place

* Engineering Editor, "Public Works," New York.

one or two faucets for the convenience of the campers, so furnishing pure water, and not tempting them to drink water of doubtful purity, as they might get it in creeks or springs at the spot near where they camp.

Mr. X. H. Goodnough.* There has been little trouble thus far from camping, which is becoming quite common just now, so far as public water supplies are concerned. But I passed a reservoir, the other day, with a public camping ground just established across the road from it, and I think that more attention will have to be given to this subject before very long. It comes within the sanitary control of watersheds, however, and I think it is easily handled if the water-works authorities choose to take care of it. I have seen no difficulty thus far in places where there is an efficient enforcement of sanitary rules.

Mr. Stephen DeM. Gage.† The turn that this last part of the discussion has taken brings a thought to me which we have recently been discussing in Rhode Island, — the fact that automobile tourists throughout the country are passing over roads which a good many times are very close to reservoirs of public water supplies, or which pass through the watersheds, near some brook which feeds into that supply.

Our sanitary facilities throughout the country for tourists are particularly poor. There are no comfort stations except in the larger cities, and people often do not know where these are. If you go touring through the country districts, you will find many automobiles drawn up at the side of the road and the people getting out and going into the woods. Of course we can imagine what they go for. If this happens to be on the watershed of a public water supply, this constitutes a possible means of contamination of that supply. We have had in the past a number of epidemics of typhoid fever which were brought about by chance contamination of water by an individual camper, — by a fisherman, or something of that sort. Just a single instance of contamination may produce an epidemic. In order to play the game safe we must take this condition into consideration as well as some of the other conditions of which we have been speaking.

Mr. Hazen. The control of this matter is purely a question of administration. I do not know that I can give any safe general rule. Sometimes decisions rest with the city and its representatives, and they are the people most directly interested and that seems to be the ordinary natural way. At other times, as we know, state authorities determine what is to be done, and not infrequently there is more or less difference of opinion and sometimes friction when the local authorities think that the requirements of the state are unreasonable.

I do not think that any general rule can be established, nor do I think that the method of procedure affects the problem of what may reasonably be done in these matters.

* Chief Engineer, Massachusetts State Department Public Health.

† Chemist and Sanitary Engineer, Rhode Island State Board of Health.

Mr. Harrison P. Eddy.* Mr. Hazen has summarized this subject very completely, but I noticed that he did not mention one thing which is very important.

We may establish as many lines of defense as we choose, and yet there remains the item of constant vigilance, which is, after all, a fundamental thing. I will illustrate my point by experience with one case, to which possibly Mr. Hazen referred, where the sewage of the small city was diverted from and treated entirely outside of the drainage area of the water supply. It would be presumed that that line of defense was effectually established. A separate system of sewers was built, which, of course, was not intended to receive street drainage and other surface water. However, in the course of some years, connections of one kind or another were made, either accidentally or surreptitiously, so that in times of storm the main sewer became surcharged and overflowed through a manhole in a public street within a comparatively short distance of a reservoir used as a part of the waterworks system. The sewage which overflowed the manhole ran over the surface of the ground down to the shore of the reservoir. That is an illustration of a lapse in a line of defense thought to have been well established, and illustrates the point that even with lines of defense, constant vigilance is required to obtain the desired results.

Mr. Albert B. Hill.† I was much gratified that Mr. Hazen gave considerable weight to long storage in large reservoirs. Those who have to do with filtration plants of various kinds have their troubles. We know that in large reservoirs the pathogenic germs cannot live very long, and that the opportunities for sedimentation and oxidation by action of winds and waves has a very important purifying effect.

There is a general feeling among laymen — the general public — that they like to have their water pure rather than reformed. If you have very large reservoirs which can be kept pretty nearly full most of the time you get the condition of large, natural lakes; but with the advantage that in the case of the large reservoirs they are generally well policed and protected, so that they soon become in the nature of large lakes of pure water. That is what the people like, rather than water that it is very necessary to treat with chemicals before it is safe to drink.

Mr. Hazen paid some attention to that. But I think that line of defense might be emphasized considerably. When we have large storage reservoirs we kill two or three birds with one stone; it is not so necessary to treat the water, — you get comparatively pure water, from the beginning, that the people like, and you get an abundance of it. These are desirable things and worth a great deal.

Mr. J. E. Garrett.‡ Is there not one line of defense which has not been mentioned? We buy land adjacent to our reservoirs and patrol it

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‡ Assistant Engineer, Hartford, Conn., Water Works.

very carefully, and filter the water; and after filtering the water, or chlorinating it, we then send it out to the city, and certain places may have other sources of supply connected with our system where the water is not so pure. It seems to me that that might be a very important line of defense, — that we should prohibit any connections with city water. As everybody knows, Hartford has been struggling with that problem for some time, and it seems that that is a very important line of defense.

Mr. Diven. I should like to hear the gentleman say what steps he has taken to do away with such pipe connections. It would be very interesting to any of the rest who have struggled with it, and usually with rather poor success.

Mr. Garrett. That particular question has been discussed in the engineering magazines, and probably everybody knows of Mr. Saville's ideas in regard to it, — that there should not be those connections,— and his point has been very strenuously fought by the manufacturers, but the board has adhered to its ruling but has extended the time a little again, so that the manufacturers may have time to eliminate their connections; and now we are all working together on that problem, and the manufacturers appear to have become of the mind that the connections should be eliminated, and the elimination of them is in progress now. Those connections about which there has been so much discussion are connections that were protected by double checks of an approved type. Other connections, which were not protected in that manner, have been disconnected a year and a half ago.

Mr. George F. Merrill.* This discussion brings up possibly another factor, the distribution system. Where the pipes are laid in the streets whether or not it is customary for some of the works to put service pipes and sewers in the same trench, or in the street to lay water mains very close to sewers. In my experience I found one case where a break in a sewer occurred and a break in the water pipe occurred at the same point. If the pressure had been reduced in the water pipe the sewage would have gotten into the main pipes from that source. It seems to me a pretty good idea to keep them a good distance apart.

* Superintendent, Water Works, Greenfield, Mass.

A DESCRIPTION OF THE WATER WORKS OF THE BRIDGEPORT HYDRAULIC COMPANY.

BY SAMUEL P. SENIOR.*

[*September 13, 1921.*]

Mr. President and Gentlemen, — In the first place, the system is practically a gravity supply. We have two emergency pumping stations, — one located at North Bridgeport and one at Fairfield.

There are four main and distinct lines of pipe coming to Bridgeport from four gravity systems. The most easterly one is what we call the Beaver Dam System.

The principal reservoir on the eastern system is Trap Falls. It has a storage capacity of 2 300 million gallons, and has an elevation of 312 ft. above mean high water.

I might say here that Bridgeport, on the whole, is located very close to high water, — between 15 and 30 ft. above high water, — so that you can see from that just about what the pressure would be.

A 30-in. pipe line comes directly into the city from Trap Falls Reservoir. It has very little drainage area of its own, but two contributory areas are piped into it by means of 30-in. and 36-in. pipe. One, Far Mill River, has a watershed of 6 square miles, and Means Brook a watershed of 7 square miles piped through a 36-in. pipe four miles long. That supplies the east side of Bridgeport, Bridgeport being divided by the Pequonnock River into the east and west sides.

The more central system is from the Island Brook gravity system. That feeds into Bridgeport through a 24-in. pipe, and Canoe Brook above it stores a 300 million gallon capacity. This is a comparatively small part of the supply. That runs in from an independent 24-in. pipe to Bridgeport.

The next towards the west is the Easton System, which includes No. 1, or Lower Easton Reservoir, and the Upper Easton Reservoir. This lower reservoir is piped direct into Bridgeport, and is fed by the No. 2 Reservoir. The lower reservoir has a watershed of about 13 square miles, and has a capacity of 200 million gallons. The upper one has a capacity of 900 million gallons. The water comes into Bridgeport through a 30-in. pipe, about three quarters of a mile of which runs through a tunnel, and is reduced near Bridgeport to a 24-in. pipe.

We have started to build a dam at this point which will impound 6 billion gallons. It will have an elevation above mean high water of 300 ft. That has been started. The plant is now set up to complete it, but owing to

* President of Bridgeport Hydraulic Company.

unfortunate conditions that prevail the work has been stopped. It was started in 1917.

The principal supply of Bridgeport comes by gravity from the Hemlocks Reservoir. This reservoir has a capacity of a little less than 4 billion gallons. It has a total watershed at the present time of 22 square miles, most of which comes from the Aspetuck River, this river being diverted by means of a low dam from its own watershed. We have planned out for the future a system whereby the Saugatuck River, west of Hemlocks, will feed into the Aspetuck and thence into Hemlocks. Our plans are made for this, the dam is designed, and the survey is all made, and much of the land has been secured. This dam will have a capacity of about ten billion gallons.

I have not said much about the Samp Mortar supply. That is an emergency supply which has to be pumped. It is on the same shed as the Easton and the Hemlocks supply. It has only a small capacity, about 200 million, and is used entirely for reserve.

About the same thing may be said of the North Bridgeport pumping station. That is located on the outskirts of Bridgeport. The pond there has a capacity of 270 million gallons, and the storage above it of 160 million from the Trumbull Reservoir and 165 million from Bunnell's Upper Reservoir.

Nathaniel Green incorporated the Bridgeport Water Company in 1853, and in 1854 built a pumping station on Bunnell's Pond and a distributing reservoir near by. In 1886 the Citizens' Water Company (a rival company) was incorporated. This company built the Easton No. 1 Reservoir at an elevation of 207 ft. above mean high water and connected it with Bridgeport by means of a 30-in. cast-iron main, an unlined tunnel and a 24-in. cast-iron main. They were enjoined from doing business, but finally joined issues with the old company and, under the name of the Bridgeport Hydraulic Company, the two were consolidated in 1888.

This company acquired the Southport Water Company in 1889 and, in 1893, the Citizens' Water Company, of Stratford. It also acquired in 1901 the stock of the Uncowa Water Company, of Fairfield. It purchased the stock of the Westport Water Company in 1916, and also that of the Shelton Water Company.

The Bridgeport Hydraulic Company now supplies water to Bridgeport, Stratford, Shelton, Trumbull. Fairfield, and Westport. The combined populations of these towns is 184 500.

The total number of service connections in Bridgeport is 23 200, and of meters, 4 700. All commercial use in Bridgeport is metered and about 1 000 domestic users. The maximum consumpton for a full year was 34.5 million gallons daily in 1918.

Due to the general depression in factories, the present consumption in Bridgeport is 24 million gallons. Based on 1920 census figures, the population supplied is 167 000. This gives a per capita consumption of 144 gal. daily.

RESERVOIR TABLE.

Reservoirs.	Capacity — Million Gallons.	Flow Line Elevation.	Drainage Area — Sq. Miles.	Water Surface Area—Acres.
(1)	(2)	(3)	(4)	(5)
HEMLOCKS SYSTEM:				
Aspetuck Reservoir	66	225.00	17.00	60.7
Hemlocks Reservoir	3 750	225.00	5.32	437.0
Entire system	3 816		22.32	497.7
MILL RIVER SYSTEM:				
Easton No. 1 Reservoir	201	207.00	1.63	46.0
Easton No. 2 Reservoir	878	262.00	12.17	150.0
Entire system	1 079		13.80	196.0
ISLAND BROOK SYSTEM:				
Canoe Brook Reservoir	293	361.20	1.60	72.0
Charcoal Pond Reservoir	12	146.00	0.18	4.1
Horse Tavern Reservoir	20	224.00	2.31	6.5
Island Brook Reservoir	300	170.85	1.61	69.0
Ox Stream Reservoir	25	198.40	0.18	15.0
Entire system	650		5.88	166.6
TRAP FALLS SYSTEM:				
Far Mill River Reservoir	40	356.25	6.08	59.6
Means Brook Reservoir	80	345.00	5.32	19.5
Trap Falls Reservoir (Reserve)	2 300	312.00	1.16	296.0
Beaver Dam Reservoir	395	170.20	0.94	59.0
Boys Halfway River	....	....	2.50	....
Entire system	2 815		16.00	434.1
BUNNELL SYSTEM:				
Bunnell's Lower Reservoir	168	31.50	6.17	50.0
Bunnell's Upper Reservoir	205	165.50	4.30	63.8
Trumbull Pond Reservoir	160	180.70	13.75	52.8
Entire system	533		24.22	166.6
SAMP MORTAR SYSTEM:				
Samp Mortar Reservoir	195	64.60	7.91	48.0

Bridgeport's water supply is collected from streams in impounding reservoirs and stored for use during the dry season. These reservoirs store, all told, 9 billion gallons, with a watershed of about 90 square miles. Most of them are high enough, 175 to 250 ft. above the city, to supply by gravity, but some are not, and to make them available there are two pumping stations which are used as a reserve. One of these is in North Bridgeport at Bunnell's Lower Reservoir, and the other is in the town of Fairfield at Samp Mortar Reservoir.

In 1917, work on a concrete dam in Easton was commenced. This dam is to be about 1 200 ft. long and 125 ft. high, and is to contain about 105 000 cu. yd. of concrete. It will impound 6 billion gallons of water. Work on this dam is entirely suspended for the present, although a very adequate and complete plant belonging to the company is installed.

It may be mentioned here that the company does its own construction work and has built five concrete dams with the same organization. It has proved to be a very flexible and economical way to handle the construction work, but this is due to the personnel of the organization. The work is conducted as nearly as may be to that of a contractor, and each working head is a man of long experience in doing similar work for contractors.

Complete surveys and plans have been made for the next development after Easton Lake is completed. This new system will be in Weston, Conn., and will be built as required. It includes a concrete dam which will impound 10 billion gallons from a watershed of 37 square miles, and a lined tunnel 6 ft. in diameter and about three fourths of a mile long. This supply, when completed, will act as a feeder to the Hemlocks dam in Easton, and will not be directly connected to the distribution system.

The company believes in buying enough land in connection with the different reservoir systems to protect the supplies indefinitely, and owns at present a little more than 13 000 acres of land. In addition to the protection afforded by long storage, the watersheds are patrolled regularly, and two outfits are kept busy during the open months, cleaning cesspools on farms more or less remote, but near enough to be possible sources of contamination. All of the water is chlorinated before being distributed, through six Wallace & Tiernan automatic outfits. A laboratory is conducted where complete chemical bacteriological and biological examinations are constantly being made by our chemists. The results obtained by these methods speak for themselves. The death rate from typhoid fever in Bridgeport for the past ten years was: 1911, 3.7; 1912, 8.1; 1913, 6.1; 1914, 3.3; 1915, 4.8; 1916, 8.6; 1917, 7.5; 1918, 4.4; 1919, 3.5; 1920, 2.1.

Two nurseries are maintained by the company, where conifers are grown from seed, to be planted on the rougher lands of the company. We are now concentrating on red pines, which, so far, have proved free from weevils, blister rust, and slugs, which play havoc with white pines at intervals. About 50 000 to 75 000 are planted on the watershed annually. Work in the nurseries is performed by men who act as overseers of near-by reservoirs, and their time is by no means wholly occupied on nursery work.

A well-equipped garage is maintained by the company, where all of the trucks and autos are housed and repaired. As materials such as coal, cement, and general supplies used on construction are hauled by our trucks, the fleet is quite extensive.

Bridgeport's distribution system includes 301.5 miles of cast-iron pipe, from 4 in. to 48 in. in diameter,—3.7 per cent. is 4-in.; 21 per cent. is 6-in.; 47 per cent. is 8-in.; 3.4 per cent. is 10-in.; 7 per cent. is 12-in.; 4.7 per cent.

is 16-in.; 6.8 per cent. is 24-in.; $3\frac{1}{2}$ per cent. is 30-in.; 1 per cent. is 36-in.; 1.7 per cent is 48-in. All pipe is purchased subject to American Water-Works Standard Specifications and is tested when made by one of the qualified testing inspectors. Practically no mains of less than 8-in. diameter are laid. The mains are laid with a cover of 4 ft.

The system has 1 767 hydrants which are owned by the city of Bridgeport but are set and repaired by the company at the city's order and expense. No hydrant rental is paid to the company by the city, although full taxes are paid. No charge for fire service is made to factories, although we require them to furnish and maintain an approved meter on each service to protect the company against misuse.

The company owns two water-front properties at the extreme easterly and westerly limits of the city. That at the easterly end is as yet undeveloped. The west end dock and yard has a dock 300 ft. long and the yard is 700 ft. deep, fronting on Bostwick Avenue. Here practically all pipe is landed and stored. Near the street, long, heavily-built platforms support gates, fittings, etc., where they can be conveniently loaded and unloaded.

A jobbing department is maintained by the company, which does most of the factory fire-service work in the city, confining its work to putting in cast-iron pipe only. Most of this work is done as subcontracts for plumbers who contract for the fire-services complete. The advantage is that, as a whole, better pipe and materials are used and better workmanship is employed than would otherwise be the case. Further than this, the company can keep and have available at all times certain men who would otherwise be laid off at times for lack of work.

In order to make use of a water power at Samp Mortar Pumping Station, an emergency station, and to keep the two men busy whose constant presence there is necessary, a feed mill is operated, where grain and corn are ground for neighboring farmers.

The company has a portable sawmill, which gets out much of the material required on construction work. Following the sawmill, choppers cut up the smaller trees and tops into cordwood, which is carted to Bridgeport and sold from two different yards as fireplace and stove wood, after being cut to required sizes by circular saw.

Discussion.

Mr. J. M. Diven.* I should like to ask Mr. Senior if the east and west sides are interconnected in any way.

Mr. Senior. Both of our systems are connected. They are balanced. It is rather a delicate thing to get them balanced. We have found times when water would back up through our Venturi's into one of the reservoirs.

Mr. Diven. You spoke of throttling the supply systems in your reservoirs, to reduce pressure. Is that by automatic valves?

* Secretary, American Water Works Association.

Mr. Senior. No, sir; just ordinary valves.

Mr. Diven. This is the first water system that has come to my attention where the percentage of 6- and 8-in. pipes is reversed. I think the insurance man ought to be very happy when he comes to Bridgeport.

Mr. Senior. We have all along believed in using 8-in. pipe for extension work, and I was pleased to see that the Government, in the camps that they built, followed the same practice; they used 8-in. almost exclusively.

Mr. Patrick Gear.* I understand the Bridgeport Hydraulic Company is under contract with the city of Bridgeport for a certain number of years at a certain price. I should like to ask what it has done for the last couple of years, and the last couple of months, to overcome the high prices of labor and material.

Mr. Senior. We have not done anything, but I will tell you we are sweating blood.

Mr. David A. Heffernan.† How long has no hydrant rental been charged?

Mr. Senior. In 1906 we had a contract with the city whereby we were to get a hydrant rental of $12.50 a year, but there was considerable opposition to that, and we have had to forego even that charge.

Mr. Heffernan. That is very unusual for a private company. In regard to the construction work, do you use any compound in joints, such as leadite or hydrotite?

Mr. Senior. We do to a limited extent in certain instances.

Mr. Heffernan. It might be interesting to know what experience you have had with compounds.

Mr. Senior. We use lead principally, and lead wool on occasions, and have experimented some with leadite, but not very extensively, although we think well of it.

Mr. Diven. The question has been brought up of no hydrant charge. Somebody, of course, pays that. If the city does not pay it out of the general tax fund, then the consumer pays it.

Mr. Senior. Surely.

Mr. Diven. It is questionable which is the more equitable, — whether to have the water consumer pay it in proportion to the water he uses, or to have it come from the general tax fund. Coming from the general tax fund it is assessed on the valuation of the property. Under this system a man having a large warehouse and using very little water pays very little for the water supplied to him for fire protection.

Mr. Samuel E. Killam.‡ What is the average head that you deliver water under in your system?

Mr. Senior. Sixty-five to 75 pounds.

* Superintendent, Water Works, Holyoke, Mass.
† Superintendent, Water Works, Milton, Mass.
‡ Superintendent, Metropolitan Water Works.

MR. KILLAM. Then you throttle it down with the valves?

MR. SENIOR. Yes.

MR. KILLAM. Do the valves wear and have to be replaced?

MR. SENIOR. No. The pressure evidently holds the slides up against the down-stream side.

MR. KILLAM. The water is pretty free from deposits of any kind?

MR. SENIOR. Yes.

MR. KILLAM. Valves throttled down the way those are usually wear out, chatter in time, and give trouble. Are the large valves at the dams operated by hand.

MR. SENIOR. Yes, they are hand-operated, gear gates. Some people might think it was a long operation, as it takes, on a 48-in. gate, about a half hour to open it. The only payment we get from the city in any way, shape, or form is that we get paid by meter at the rate of 3 cents a hundred cubic feet for water used in schools and fire-engine stations, and for general muncipal uses. The total amount of that is about $5 000 a year.

MR. THOMAS J. CARMODY.* To what extent do the manufacturing industries install sprinklers?

MR. SENIOR. They all have sprinklers.

MR. W. C. HAWLEY.† It would be interesting to know what the rates for industrial and domestic consumers are, in which the cost for fire protection must be charged.

MR. SENIOR. For commercial use we sell about 48 per cent. of all our water through meters, and for that we get an average price of 4.4 cents a hundred cubic feet. Our flat rate for the ordinary single dwelling is $12 a year; for a two-family house it is $22, or $11 a family.

MR. HAWLEY. I don't know how you do it.

PRESIDENT SHERMAN. I doubt if there is one of us who would know how it is possible to do that without a tax levy to draw on to support it.

MR. SENIOR. It comes hard. Everything is metered except domestic consumption, and domestic consumers may have a meter if they like; it is optional.

MR. JOHN H. WALSH.‡ In metering the large consumers, do you use compound meters?

MR. SENIOR. We have a few, but not many

MR. WALSH. Do the underwriters find any fault?

MR. SENIOR. They object to the compound meter, but allow them.

MR. ALBERT B. HILL.§ There are one or two points that Mr. Senior slipped over rather easily on personal matters. The first is that the company does its own construction work, and that the work is conducted, as nearly as may be, along the lines which would be followed by a contractor. The Bridgeport Hydraulic Company has gained a great deal by that.

* Water Commissioner, Holyoke, Mass.

† Chief Engineer, Pennsylvania Water Company.

‡ Superintendent, Water Works, East Hartford, Conn.

§ Consulting Engineer, New Haven, Conn.

There is another point that might be emphasized, and that is the future of this work. When the work now under way is completed, Bridgeport will be well fixed for water. They will have then something over 20 billion gallons in storage. Their consumption is, I should say, something like 10 billions, so that they will have water that can be stored for a long time, and the importance of long storage of water in reservoirs cannot be too highly emphasized, when the typhoid germ cannot live more than about two weeks in such water. The oxidizing effect of wind and wave in large reservoirs is very advantageous to the water.

Mr. Carmody. Is there any reason assigned why Bridgeport should not make the manufacturers pay for the water used in sprinklers?

Mr. Senior. There is a sentiment in Bridgeport against it, for the reason that they say that they practically do not use the water, and ought not to pay for it. It is not a proper line of reasoning. I think that the service rendered is of great value, and ought to be paid for.

Mr. Carmody. Then why does not your company compel them to pay for it?

Mr. Senior. They are more powerful than we are.

Mr. Carmody. I was going to say, Mr. Chairman, that we have that question in Holyoke now. That is, we charge the city of Holyoke $8 a hydrant a year for fire purposes, and have just notified the manufacturers that we intend to make a charge in the same manner and have them pay for the private fire protection. We believe they are using large quantities of water in opening the sprinkler heads or breaking the sprinkler valves. The manufacturers rose in a mass against it. We have not settled the question yet, but I believe that they will be compelled to pay in some way. The question is, In what way should they be charged; should we charge them for the sprinkler heads, or should we charge them for the main connection? I suggested a service charge of from $50 to $100, according to the size from 4- to 10-in. pipe.

Mr. Senior. You say you charge $8 per hydrant. That is almost the same as charging nothing, compared with the value of the service.

President Sherman. Holyoke is in the rather unusual condition of being able to get a hydrant rental from the city, with a city-owned plant. There are not very many of our municipal plants which are fortunate enough to get hydrant rentals from the city. On the other hand, so far as I know, Holyoke is practically unique in paying taxes to the city from the water department, so that to a certain extent it is a stand-off. Just how close it comes to an actual stand-off in money I am not informed. But they are not as badly off as you are here in having to pay taxes and getting nothing back.

I think there are probably no water-works men who would not say that if services are rendered by the water department, whether they include the furnishing of water or not, but what they should be paid for. It certainly is up to the water department, either privately or publicly

owned, to furnish a water supply of adequate capacity, or of suitable size, to properly take care of fire protection. There is an investment upon which fixed charges must be paid, even though no water is used, and somebody has to put up the money for those fixed charges. Now, the parties benefited by receiving the fire protection are ordinarily the ones that should pay for it, as I see it, and I think practically every water-works man takes that point of view. On the other hand, when it comes to what you can actually get, if you are a municipal department you are lucky if you get anything, and yet from Mr. Senior's experience I don't know but you are equally lucky if you get something in the case of a private company, although most private companies do get something.

Mr. Heffernan. I should like to ask in regard to the privileges given to the city departments, such as the sewerage, highway, and so forth, in using the hydrants. Do you give them full sway, or do you protect your hydrants by sending an employee of your department?

Mr. Senior. The city uses the hydrants practically as they please, but they have inspectors look after them. When we grant permission we give permits. It is done only on permit.

THE REPAIRS TO THE STANDPIPE AT BATH, ME.

BY CLARENCE E. CARTER* AND WALTER F. ABBOTT.†

[*Read September 16, 1921, by George A. Sampson.*‡]

The standpipe of the Bath Water District was built as a part of the original system of the Maine Water Company, for furnishing water to the cities of Bath and Brunswick, Me., and is located on the main pipe between these cities, on an exposed hill about one and one-half miles west of the center of Bath. The top is at elevation 247.33 ft. above sea level, or about 222 ft. above the ground at the City Hall.

The original contract for the construction of this standpipe was as follows:

Contract for Bath Standpipe, dated January 12, 1887. Between the National Water Works Syndicate of Boston, Mass., and the New England Ship Building Company, of Bath, Maine.

Structure to be located on leading main of the Bath Water Works, about 1½ miles westerly from Court House.

Mean interior diameter of about 34 ft.

Clear interior height of 74 ft.

Iron, C. L. Bailey's refined iron stamped "Central," or iron equally good. Tensile strength in every sheet of not less than 50,000 lb. per square inch of section, at any point.

Lower three (3) rings not less than 9/16 in. thick.

Next three (3) rings not less than 8/16 in. thick.

Next three (3) rings not less than 6/16 in. thick.

Next three (3) rings not less than 5/16 in. thick.

Upper three (3) rings not less than 4/16 in. thick.

Bottom plates are to be 1/2 in. thick.

Manhole 11 x 15 in. clear opening.

The stone walls, filling and iron bearing bars are to be furnished in place by party of first part (National Water Works Syndicate) and the bottom plates are to be well bedded in coarse mortar by party of second part (New England Ship Building Company).

Inside to be covered with two good coats Warren's black varnish for metals.

Outside to be covered with two good coats of Prince's metallic paint.

Work to be completed on or before June 1, 1887.

Consideration, $8,200 or $8,000.

All rings are 5 ft. in height, with lapped vertical and horizontal joints; the horizontal joints on the lower side of the bottom sheet being double riveted, all other horizontal joints single riveted, and all vertical joints double riveted. The upper top of ring was reinforced by a 3-in. angle iron made up by a series of short lengths.

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* Assistant Engineer, Metcalf & Eddy, Boston.

† Superintendent, Bath Water District.

‡ Of Weston & Sampson, Boston.

Standpipe at Bath, Me., after Failure due to Wind Pressure during Gale of December 14, 1917.

Looking Northwest.

Looking West.

Looking Southwest.

During a heavy gale on December 14, 1917, a section on the easterly side of the standpipe, extending down about 35 ft. from the top, failed, as shown in the accompanying illustrations, on account of the excessive wind pressure. The records of the Weather Bureau at Portland, Me., show the maximum velocity of the wind on this date to have been sixty miles per hour. The lower limit of the damaged section was at the level of the water in the standpipe at that time.

The standpipe was operated with the remaining available depth of 40 ft. until the later part of the summer of 1919 (over one and one-half years), when the Water District contracted with the Bath Iron Works, of Bath, Me., for its repair and restoration to full capacity.

For the prosecution of this work, the contractors installed at the site a portable boiler, to supply power for the steam hoists which handled the plates, and an air compressor for riveting. A staging was erected on the outside of the standpipe and a float placed on the inside.

Each plate was carefully marked, the rivets "busted" off with hand hammers, and the plate lowered to the ground. The plates were then hauled by trucks to the local plant of the contractors, re-rolled to original shape, and then replaced in the structure. In all, 27 plates were removed, 24 being re-rolled and 3 new ones furnished; those which came at the lower extremity of the damaged section being broken so that they could not be repaired.

In re-setting the plates, each ring was completed, and then the water level in the standpipe was raised sufficiently to bring the inside float to the proper working level for placing the next ring. Control of the level of the water in the tank was maintained by means of temporary telephone connections with the superintendent's office, and the superintendent in turn regulated his pumps to produce the desired result. After all of the plates had been replaced, the top of the upper ring was reinforced by a $6 \times 6 \times \frac{5}{8}$ in. angle iron in 18 ft. lengths, and four steel wire guys (1 in. in diameter) were fastened to the quarter points of the top and anchored to the ledge about 100 ft. from the base of the standpipe.

As the bottom needed some attention and the paint needed renewal, the water was drawn out and about 1 ft. depth of concrete was placed over the entire bottom, and the structure was given two good coats on the inside and one on the outside of Detroit graphite paint.

The time consumed in making all repairs is divided as follows:

Repairs to the plates	43 days
Concreting the bottom	2 days
Painting	4½ days
Total	49½ days

The structure was entirely out of service during the concreting and painting only a period of six days, and during this time water was pumped

directly into the distribution system, which was protected by two relief valves, one being at the Nequasset Pumping Station, which is about $2\frac{1}{4}$ miles east of the city or $3\frac{3}{4}$ miles east of the standpipe, and the other being at the Thompson's Pumping Station, which is about 2 miles west of the standpipe.

The cost of the work was as follows:

Repairing of plates	$5,408.81
Additional bracing and concrete bottom	1,437.82
Painting	291.63
Total	$7 138.26

The total cost, for repairs only, is an average of $215 per year since the construction of the tank, — the painting cost about $11\frac{1}{2}$ cents per square yard per coat, but this cost excludes some additional expense which would have been encountered had the painting been done at some other time as an entirely separate job.

The details and costs contained in this article were furnished by Mr. Walter F. Abbott, superintendent of the Bath Water District, who is a member of the New England Water Works Association.

Discussion.

Mr. I. T. Alstrom. What method is used to signal to the pumping station when the tank is overflowing? Does that ever happen?

Mr. Sampson. There is no method except to get the height by the pressure gage at the pumping station, and that is affected by the draft in the city so much that it is unreliable. The water company owns the hill, and, as there are no houses within, I should judge, a quarter of a mile of the tank, there is no danger from overflowing.

Mr. Alstrom. In our town we only own a few hundred feet around our tank, which has been overflowing so that the man who owns the land near the tank has been threatening to bring suit against the town for washing his land. We have just established an electrical system whereby a horn is blown in our pumping station until the engine is shut off and the water gets down to the regular level, which is 2 ft. from the top of the tank.

President Sherman. Some sort of telltale at the pumping station is almost essential to a proper operation of the standpipe, of course, but a great many water-works systems are still getting along with such information as they can get from their pressure gages, and taking chances otherwise.

THE CONTROL OF WATER WASTE BY HOUSE-TO-HOUSE INSPECTION.

BY GORDON Z. SMITH.*

The Bridgeport Hydraulic Company serves water to the city of Bridgeport, towns of Stratford and Fairfield, the boroughs of Nichols Farms and Long Hill.

The estimated population served, based upon the census of 1920, is 167 000.

There are 23 194 service connections, on which there are 4 673 meters, classed as follows: 2 780 commercial, 1 763 domestic, and 30 test meters. There are 22 500 customers' accounts for water billing.

The inspection service is intimately connected to the water charge accounting, for it is the basis for all charges except, of course, meter accounts. The inspector enumerates upon a blank the water fixtures upon any service, number of families, stores and shops, and whatever the character of the use. The charges therefor are entered upon the slip, totaled and transferred to the ledger card bearing the same account number as the completed inspection blank. As changes occur, either addition or disconnection of fixtures, a new inspection slip is filed in place of the old one, and the proper entries made upon the ledger card. Notice of the additional charges are then sent to the owner. Vacancy claims, disconnections, additions and new buildings are all verified and reported by the inspector. Inspectors are chosen for their fitness and adaptability in their work. Courtesy being the foundation of our relation with the public, we insist upon it first and last, with the result that there are very few complaints made at the office.

As a secondary but an important feature of the inspection service is the leak detection. The inspector reports all leaking fixtures and pipes, and sends notice to the owner requesting repairs be made. This request is followed by a reinspection to ascertain if repairs have been made. If not made within a reasonable time, a special letter is sent to the owner stating that if repairs are not made within a specified time a meter will be set because of the leak. That is also followed up, and if not repaired the owner is notified that a meter will be set.

Two or more years ago it was necessary to set many meters for the above reason, but at present repairs are made with considerable dispatch.

Premises in which leaks are found upon every inspection, but repaired after repeated notices, are selected, and the owner is notified to keep such

* Chief Inspector, Bridgeport Hydraulic Company.

premises free from leaks or a meter will be set, and if leaks are found after such notice a meter is installed after due notice to the owner.

Many underground service leaks — leaks which do not appear on the surface — are found by our inspectors by shutting off the house supply in the cellar and listening to the pipe with a water-phone.

During the extreme cold weather the inspectors make special inspections of premises in which the pipes and fixtures are known to be in an exposed location, and if found to be running to prevent freezing a special letter is mailed to the owner with a warning that the practice must cease, and if found a second time a meter will be set forthwith. This is also checked by a reinspection, and if found running a second time, a meter is set.

The inspection force is large enough to cover unmetered service twice a year, together with all other reinspections and miscellaneous work. This requires a total of nearly 60 000 reports from five or six inspectors.

General Results.

While we realize that a 100 per cent. metered system has many advantages, there are also disadvantages. It is not within the purpose of the author to discuss that in general application; however, it may be said that metered service is the fairest method of selling water, and we may all come to it as a last resort.

The attitude taken by the Bridgeport Hydraulic Company toward this subject is governed by the peculiar conditions, and in some instances universal conditions, to be met in our customers. The supply at present and since 1918 has been by gravity from a long-time storage, with treated water. The highest daily average for one year was 1918, when it reached 34 000 000 gal., 47 per cent. of which was charged by meter. The highest daily average for one month, that year, was in January, with 41 000 000 gal. Some days the rate exceeded 44 000 000 gal. In 1919 the daily average was 29 000 000 gal., of which 49.6 per cent. was metered to the consumer. In 1920, the daily average rose to nearly 32 000 000 gal., of which 50 per cent. was metered. For the seven months of the current year the average daily consumption was 24 000 000 gal., of which 47.8 per cent. was metered. The above records are from Venturi meters and service meters. It will be noted that with about 20 per cent. of our services metered we actually account for and charge for 47.8 per cent. of our water by meter rate. In 1920 our meter billing charges were nearly equal to the flat rate charges.

It can be said that in some cities, with every tap metered, only 50 per cent. of water can be accounted for. According to the State Board of Health of Massachusetts, 1900, no city of the state having over 90 per cent. of the taps metered accounts for over 62 per cent. of the water furnished.

Therefore it would appear that our meters are being placed where they are most effective, also that our per-capita consumption is high, but not excessively high after all the proper allowances are made for losses that

would not appear upon the service meters. The per-capita daily consumption for this year to July 31 is 144 gal. No floating or transient population was estimated. Deducting the metered use leaves a balance of 75 gal. for flushing, fire protection, underground leakage from 300 miles of mains and 23 000 services, does not leave such a large amount for unmetered domestic use and for leaks from household pipes and fixtures.

Mr. Dexter Brackett, 1895, stated that it is not practicable to reduce waste below 15 gal. per capita in large cities, and that this figure can be reached only by universal use of meters.

Just what the domestic allowance should be for our system is undetermined, but by assuming a fair figure, say 50 gal., we shall have something reasonable as a working basis.

It may be said that the above is large, but the conditions are a bit different here than the average city. The people have always been told that there would be an abundance of water for their use, and it is believed that they use it accordingly.

If, as stated above, 15 gal. is allowed as waste which meters would not eliminate and 50 gal. as a fair allowance for domestic use, we have a remainder of 10 gal. per capita per day for the meters to save for us, which is 1 670 000 gal., which for one year amounts to 609 000 000 gal. If capitalized at $58 per million, which is our average rate for metered water at present, equals $35 000 revenue from estimated waste of water. Let us now check the cost of saving this amount against the cost of meters and the public sentiment against meters.

We will require 19 000 meters installed at a cost of $22 per meter, which would amount to $418 000 at 6 per cent., equals $25 000 interest charge. Four per cent. for depreciation and retirement charge equals $16 720. Cost of reading meters, repairs, and accounting might easily reach $19 000. This totals $60 720 as a fixed charge per annum against meters. Therefore we may say that our income might be increased $35 300 per annum by spending $60 720.

There is the almost universal opposition to meters upon domestic supplies for many reasons which demand recognition.

It would appear to us, therefore, that with the power to install meters where the use is large and of a nature to be beyond control or unreasonable domestic use and for waste after notice to repair, we effect an excellent working balance by controlling the house fixture leakage through inspection and insisting on prompt repairs. By this method a large percentage of our consumers have the use of water for domestic purposes without a thought that every drop used is measured. It enables our Company to operate on a very liberal basis so far as the domestic consumer is concerned, and our experience has been that a great majority of water-takers appreciate the situation and do not wilfully waste the water. We have been able, by close coöperation with users, to feel that the public is educated in belief

that this company is living up to a very liberal interpretation of its charter obligations to give the community a wholesome quantity of pure water at a reasonable charge.

Discussion.

President Sherman. We have heard a great deal, in recent years, in favor of 100 per cent. metering. This is the first time we have had a real presentation of the other side of the case for a long time, if ever, in this Association. The paper is before you for discussion.

Mr. Carleton E. Davis.* I notice that you deal with the owner of the property. Does the owner ever blame the tenant for wasting water; and if so, how do you handle that situation?

Mr. Smith. We have a great many of these complaints, naturally, because Bridgeport is a city containing a good many tenants; but the owner is the man who pays the water bill, and we have to look to him for the responsibility. If he can't keep his tenants responsible to him, certainly the tenants would have no dealings with us.

Mr. J. M. Diven.† High economy in the use of water is probably less important in Bridgeport than in places where the water has to be pumped, maybe pumped, filtered and again pumped. A gravity supply with ample water does not stimulate water-waste prevention as more difficult and expensive supplies do. The speaker's experience is that house-to-house inspections do cause friction, as some people seriously object to having the inspectors go through their houses to look for leaky fixtures; they consider it as much an invasion of personal rights as a search for hooch.

The writer spoke of the reasonableness of notifying property owners before setting a meter; the speaker thoroughly agrees with him in that. The speaker's practice has been not only to notify them before setting a meter but also to put the meter in on trial for a month, then have a reading taken and the result, with a statement of the cost by meter measurement, sent to the owner, and a notice that the meter rate would commence a month from the date of the first reading, thus giving a month to repair leaking fixtures or install better ones before the meter charge began. In some instances meters are set without even the knowledge of the property owner, his first knowledge of the fact being the receipt of a large water bill, which is a manifest injustice.

Mr. Smith. There is almost no friction at all here among the occupants of houses in letting the inspector in to inspect the water pipes and fixtures. The system has been in operation here for some time, and people expect the inspector twice a year. If there are leaks in the house which the landlord doesn't repair, they like to have the inspector come around. We

* Chief, Bureau of Water, Philadelphia, Pa.
† Secretary, American Water Works Association.

have a good many reports from tenement houses where there are leaking water fixtures, — "Please send up an inspector and get the landlord to repair it."

Major Robert C. Wheeler.* On the question of metering generally, when I first took charge as manager of the water company at Chester, Pa., I found that the water accounted for was something around 72 or 73 per cent. of that which was pumped. Now, the first thing I did was to improve the facilities for testing the meters, and that campaign proved very much worth while, because we increased the water accounted for to about 80 per cent. That is, we were able to collect for 10 per cent. more water than we had done.

We were not as fortunate as Bridgeport, because we had to pump and filter all the water, and our lowest rate was something like 10 cents a thousand gallons, so that the increase in revenue was considerable. One reason why some people are disappointed in their experience with meters probably is that they do not test them frequently enough and do not keep them in such a state of repair that they register as they should.

Mr. W. C. Hawley.† Replying to the question which Mr. Davis asked, it seems to me that the owner is the man who is responsible for the character of the tenant, and that he, therefore, has the responsibility for the water bills, — at least, to a certain extent. Our company goes on the principle that it will deal only with the owner. He can protect himself by occasional readings of the meter, and by proper maintenance of his plumbing, so that there should not be any serious difficulty there.

I believe under the conditions which Mr. Smith has outlined that he is perfectly justified in not metering a large proportion of his consumers. A study which I assisted in making a few years ago, of a city in central Pennsylvania, showed that where they had an abundance of water and their flat rates were already low, it would have been very difficult to introduce a meter system. It probably was not necessary. But the day is coming, when they approach the limit of their water supply, when they will be forced to meter, and I believe Mr. Smith is gradually approaching a 100 per cent. metered condition. My experience has been that the objection to meters on the part of the consumers is a matter of education, and that within a short time after the meters have been installed there is just as much sentiment in favor of the meters as there was previously against them. With the pressures that you have here in Bridgeport I see no reason why a larger percentage of water should not be accounted for. In our own case, with pressures in our distribution system ranging over a large proportion of it, from 125 to 160 lb. and in parts of it at more than 200 lb. to the square inch, we account for 75 per cent., and in some years we have accounted for something over 82 per cent. Of course we are 100 per cent. metered. But in making that estimate we have not allowed anything for

* Of Horton, Barker & Wheeler, Engineers, Albany, N. Y.
† Chief Engineer, Pennsylvania Water Company.

water used for fire or street purposes, or leaks, or any other use than water actually measured.

Mr. F. A. McInnes.* We were forced, in Boston, under state law, to meter all new services and 5 per cent. of existing services each year, beginning 1908. We anticipated all kinds of trouble which has not materialized; in fact, as far as the consumer is concerned, our difficulties have been practically negligible. The installation of meters began in Charlestown and East Boston, at the northerly end of the city, and the work is progressing southerly through the city. The trouble is to keep within the designated section, as hardly a week passes that we are not asked to set meters outside of the area in which the work is being done. Mr. Hawley has expressed it exactly when he said that when the people know they are going to have meters they soon become educated to them.

We started in 1908 with 5.7 per cent. of our services metered, a daily average consumption of approximately 98.4 million gal., a per capita of 158 gal. and a population of approximately 623 000 — I am using the old census, Mr. Killam. Eight years later, with 53.2 per cent. of services metered, we were using 77.6 mil. gal. of water with approximately 126 000 more people, a per capita of 104, and a reduction in the total daily average amount of water delivered into the city of about 21 000 000 gallons.

During the years 1917–1918 the installation of meters was suspended by special enactment of the legislature. The work is now again in progress.

Ours was a case of must. We had to spend money to put meters on every service or face a very large expense for our portion of the cost of extending the works of supply.

I do not consider house-to-house inspection a success, in a large city at least. It is not sufficiently enduring and does not stop very serious cases of waste, such as faucets being left open carelessly, for cooling purposes, etc.

It has been our experience that those who use water without stint, and don't waste it, find their bills satisfactory. The few who waste water carelessly have been paying out more money than they did before.

Mr. Smith. I want to correct one statement. In my paper I made no estimate of water that we account for; but if we were 100 per cent. metered it was assumed we ought to account for 100 per cent.

We receive pay for 50 per cent. of our consumption by meter charges, in addition to what we sell on flat rates.

Mr. H. V. Macksey.† It looks as though the present speaker had made a good case for his own city and his own company.

It was some years ago that I had something to do with the meter system, so-called, of Boston. One of the reasons why the people despised the meter, and hated the meter inspector in Boston at that time, was because the meters were not practicable, durable, fair-measuring machines.

* Division Engineer, Boston Water Department.
† Superintendent, Public Works, Framingham, Mass.

The city was full of meters that should have been scrapped. Boston would never be metered to-day were it not for the fact that they are buying water by meter and that the statute compelled them to sell by meter. They are now doing good work, and, as far as I can gather, the people of Boston are not dissatisfied.

Since that time I have had something to do with the water works of two small towns or cities. In the first one when I went there, a fund was provided to purchase meters and put them in service when water takers should ask for them. A few of the water takers knew a thing or two and asked for meters, as the rates were so arranged that they would save money. Others thought the meters were no benefit and didn't want to be bothered with them. The Board of Public Works couldn't agree upon whose meter to buy, so that the fund lay there for several years and people got no meters. When I took charge of the system I pointed out to some of the people that they better ask for meters, and we soon used all that money and had to apply for more meters. That was because our rates were arranged so that they gave an advantage to the man who was economical and saving.

Now, it may be possible that in the city of Bridgeport, by inspecting twice a year, you can keep down leaky fixtures; if so I think you have pretty nearly reached the miraculous, because with ordinary plumbing if the average ball cock runs for a year without leaking it does very well. When you find small leaks that seem trifling but which you ought to stop because you know they are going to become larger day by day, the owner objects to incurring great expense for a little water, and the plumber will say that it doesn't amount to anything. Now, if you are a private corporation and deal with the owner, you can shut the water off.

If the works are owned by the municipality, it is different, because you will find a man who sits in judgment in the matter of water rates, but he is likely to be a supplicant a short time before the next election, and so he wants to be not only fair but generous in some cases, and you can't blame him. And if you have, as we have in the town that I am now in, a law that compels you to furnish water to any man who asks for it, he makes his initial payment, whether he be an owner or a tenant, you then have another complication. We have many cases where the tenant wastes the water, has a big bill, refuses to pay, and we shut off the water. The Board of Health then tells us that it is a matter of health and we must supply the water. They do not tell us anything about who is to pay the bill. The tenant then starts anew, makes the initial payment, and everything goes along very finely until he wastes some more water and then refuses to pay. Of course you have a claim against him, but these small water bills are not collectible in court, as they are too trifling, and where the money is owed to the municipality your chance of collection is very small. There are many reasons why a meter service is to be preferred in a municipally operated plant where it would not be in one that is operated by a private corporation.

There is one thing that we all must consider, which was touched upon by Mr. Hawley. In a great many water systems we are approaching the limit of our supply. It is not a matter of money alone; it is a matter of safety and of large expenditure later on. In the departments that I have had anything to do with, I have always tried to enforce a rule that no man may waste water, even though he pays for it.

I am very much interested in the success of the plan as carried on in Bridgeport, but have my doubts as to whether it could be successfully applied in the various cities and towns that I have been in touch with in Massachusetts.

Mr. Albert B. Hill.* In the case of Bridgeport, as indicated by Mr. Smith, it seems to be at the present time more economical to sell water at the flat rate, because there is plenty of water and a gravity supply; but when the time comes that they get about to the limit of that supply and additional water must be supplied at great cost, then conditions will be different. It will be found that the average property owner, if he has a metered system and his attention is called, by the bills or by the inspector, to the fact that he is wasting water, will give prompt attention to making repairs. On the other hand, if he pays on a flat-rate system and his bills are just the same whether he wastes a lot of water or whether he does not waste any, he is likely to give very little attention to the matter.

Metering will enable large expenditures for additional supplies to be postponed.

Mr. Walter P. Schwabe.† We have heard from the large companies principally, and I might relate the experience of a medium-sized company in Thompsonville, Conn. In 1915 the entire system was metered, about 1 800 meters being installed. The city is supplied by springs that have a yield of approximately a million gallons a day, and that supply seems to be very regular the year around. Previous to that time, during the summer, and sometimes in cold weather in the winter, the demand would exceed that million gallons a little, and the storage supply would be cut down so that the company would notify the consumers to stop the waste of water, or to stop the sprinkling of lawns and the sprinkling of streets. As a matter of fact, they bought a gasolene pump to fill the water carts from a creek in 1914.

Since 1915 we have been encouraging the use of water. During the war I advertised how much better their gardens would grow if they would put water on them, and we sold this water at 50 per cent. of the regular price for water, to encourage the use of it. We cut down the daily consumption perhaps between 30 and 40 per cent. There was considerable opposition to the installation of meters. After a year with meters our records showed that 70 per cent. of the residence consumers were paying less for water than they did on the flat rates. To-day you could not change

* Consulting Engineer, New Haven, Conn.
† President, Thompsonville, Conn., Water Company.

them back. This system has been very beneficial to the consumers as well as to the company.

On the other hand, another small system that I operate is a gravity system, and it is impossible to figure the proposition of metering. We have plenty of water, and I do not see how we could earn anything additional to compensate for the investment and upkeep of the meters. The operating expense would be materially increased in this little plant if the services were metered — approximately 500. I do not see any way of getting any additional revenue. It is not necessary to meter, because there is a sufficient supply of water. It is evident that the question of metering or not metering depends on the local conditions.

Mr. William A. Mackenzie.* The place I represent, Wallingford, Conn., has 1 700 taps, about 18 per cent. of the services are metered, from which we derive about 40 per cent. of the total revenue. It is a municipal company and we permit meters to be installed on house services upon application and also set meters where necessary to prevent or stop leaks.

It seems to me, whether it is a private or municipal water company, — although in our case we have a large surplus of water, which makes it more advisable to slowly come to the metered system,—that the meter rate is the more equitable and will eventually be the method of collecting most water rents.

In private companies it is very necessary and also with municipal companies, to avoid troubles and disputes with the consumers, for the best of relations and coöperation must be maintained. It is the best plan to increase the number of meters gradually, and thereby prevent the troubles that are bound to come if we attempt a 100 per cent. metered system at once, or when there is an abnormal growth and excessive use of water beyond the capacity of the plant.

Mr. Allen Hazen.† A few years ago the president of a water company told me of his experiences. He was serving a ground water supply of excellent quality but of limited quantity, to a growing community, and he had made up his mind that the only way that he could continue to meet conditions was to adopt meters. His takers were opposed to the meter system, but he knew something of human nature and of the people he had to deal with. He announced publicly and emphatically that he did not believe in meters and he instructed his superintendent not to set any more of them. The people soon became excited, and there were some arguments to which he finally yielded as gracefully as he could. Fifty-one per cent. of his services are metered to-day, and the rest are following.

Mr. Lincoln Van Gilder.‡ In our town there is about 65 gal. per capita consumption on the actual population, — not the summer population. In a neighboring town they are using about 200 gal. per capita, and they

* City Engineer and Superintendent, Water Works, Wallingford, Conn.

† Consulting Engineer, New York.

‡ Superintendent, Water Works, Atlantic City, N. J.

are very hard put to it for money to keep going. They are in a quandary whether to spend $40 000 by increasing their pumping and filter beds, which takes no account whatever of other expenses in connection with the increased supply. It is a question of the strength of the gridiron system to carry the water to them.

I should like to ask Mr. Smith if in making up his tabulation he figured out what it cost them to make their house-to-house inspection, per annum.

Mr. Smith. I think, about $11 000.

Mr. Diven. In this town you speak of as using so much more water than you, they may have more manufacturers.

Mr. Van Gilder. They have not any more manufacturers than we have. They have two glass manufacturers there, which are not very heavy users of water.

Mr. Diven. Then you have the ocean to bathe in.

Mr. Van Gilder. It may be interesting to know that the days on which we have the heaviest bathing in the ocean we have the heaviest pumping, because every bath means a shower bath and the washing out of the bathing suits.

Mr. Hawley. Mr. Van Gilder's statement of 65 gal. per capita is very interesting to me. I remember in 1896, when I took hold of that plant, the per capita consumption was from 250 to 260 gal. We began by making a house-to-house inspection — which, by the way, increased considerably our flat-rate revenue by finding hundreds of fixtures which had been put in but not reported by the plumbers, — and where we found leaks we told them that if the leaks were not stopped a meter would be set. That was more effective than a threat to shut off the water. We succeeded in getting through the following summer without the water shortage which had been encountered during the two previous seasons, and within two years the per capita consumption was down to between 50 and 60 gal.

I am reminded by what the last speaker said that there are cases where water is used, where spigots and so forth are permitted to run, that inspection will not catch. I have in mind where a house with a $5 minimum rate had a $30 bill for six months, and the inspection showed that the woman who lived in the house had an idea that to permit the hopper water closet to run a couple of hours every morning was a proper and sanitary thing to do. That is where the water had gone. The inspector might have caught it or he might not.

I do not see why there should be the objection to meters that there apparently is in some places. A meter places the burden where it belongs. If a man does not use much water there is no reason why he should pay for what someone else uses, and if he uses a great deal of it he should pay for it. It is the only just method of distributing the burden.

Mr. Davis. Touching on the tenant and landlord question once more, if the real object is to save water irrespective of collecting revenue for all the water used, I believe there must be some responsibility upon both tenant

and landlord, for paying for water used. I know of a case where a certain tenant has wasted water in order to run up a bill on the landlord so that the landlord would be willing to sell at a reduced figure to the tenant. In these days, particularly of late, I think the tenant out of spite frequently does use considerable extra water.

If we are determined to stop water waste irrespective of who pays for it, I think something must be done to place some responsibility upon tenants.

Mr. Hawley. We take care of that situation to a certain extent by offering to the owner, if he does not care to read his meter, to make a monthly reading of that meter for a normal fee and report to him by post-card, so that he has tabs on the amount of water that is being used, and, at any rate, he knows within thirty days if there is any considerable increase in the amount used and has an opportunity to protect himself.

Major Wheeler. My experience along that line seems to indicate that it is difficult, although it is not impossible, to make the owner responsible for the water bill. In a very small number of cases, in dealing directly with the tenant, has there been money lost through the failure of the tenant to pay before he moved, or for some other reason, and the amount has been very slight. We always have had a good deal of trouble with the landlord, who said that he was under a contractual relation with his tenant through the lease and he had no way of really controlling how much those water bills should be.

Mr. Michael F. Collins.* Speaking about tenants and water meters, I think there is another class of people that we have to consider, too, and that is the manufacturers. A good many of them we would never accuse of anything wrong. But I have one factory in whose neighborhood every Saturday afternoon and Sunday I had numerous complaints about rusty water. I consulted the master mechanic of the establishment and asked him if he knew any cause for it, and he said, no, he did not use any water to cause it. Finally it got so bad I went to him and said we would have to put a meter on. It happened to be a 10-in. service. We made installation, and I want to tell you, gentlemen, now, what I think will surprise you: The first full quarter we got $750 out of a concern that never had used any of our water before.

So I think, as far as the meters are concerned, they are most justifiable, and every service ought to be metered, both in justice to the city or company and the consumers.

Mr. Van Gilder. In regard to the responsibility as between the landlord and tenant for the water bills, it is very frequently done in our town, when the leases are drawn, — to have the landlord held responsible for the minimum rate and the tenant to pay the excess. I do not recall a single case where there has been serious difficulty in collecting on that basis.

* Superintendent, Water Works, Lawrence, Mass.

We collect from the owner, of course, and he in turn goes back to the tenant.

President Sherman. It seems to me that Mr. Van Gilder has a method that should be followed much more commonly, and one of which our real estate men might take some cognizance, especially with the increasing friction which may result between the landlord and tenant on meter bills.

For instance, I have personally recommended, in cases that have come to my attention, that leases be drawn providing that the tenants shall assume the water rates. But that has nothing to do with the method of billing, which, in almost every case with which I have come in contact, has been to the owner. It is merely a matter of who shall make the payment. The owner receives the water bill and turns it over to the tenant. If the tenant does not pay the bill the water is shut off. Of course if the tenant leaves with an unpaid bill the department collects from the owner. But, taking it by and large, that method works out the best of any that I have known of being tried. It is not customary among real estate men to draw leases in that way, but I can see no reason why they should not do so.

Mr. Hawley. We go a step further. We deal with the owner, but when the owner says, "I want the bill to go to the tenant," we send the bill to the owner in care of the tenant, and it is up to the tenant to pay the bill, though the ultimate responsibility is still with the owner. In our district nearly all leases specify that the owner shall pay the minimum rate and the tenant shall pay any excess. This, of course cannot apply to apartment houses.

Mr. M. N. Baker.* There is one question which it seems to me enters into the question as to whether it would pay to install meters in Bridgeport, which I think has been left out of the account. That is, if this water were saved, the date for getting more water would be postponed. I think some credit should be allowed on that account. In going over the water-works system yesterday I saw a big cableway where I was told that they were just waiting time before they put up a 150-ft. dam to impound more water. If the date of building that and other impounding reservoirs were to be postponed, by the installation of meters, certainly something ought to be credited to meters on that account.

Mr. Hazen. Although a digression, I think another matter relative to meters appropriate at this time. Some years ago this Association had a committee on meter rates, and, after a long deliberation and much discussion by the Association, the Association adopted a form of meter rate in which the quantities of water under the successive steps of the schedule were standardized; and that meter rate adopted by this Association, I am happy to say, has been adopted in a great many cities, supplying hundreds of thousands of services with water, and I have recently been writing to the places where it has been used, as far as I knew of them, and asking for the

* Associate Editor, *Engineering News-Record*.

results, and they have usually been very satisfactory, — they have gotten along with comparatively little friction.

At the meeting of the American Water Works Association in Cleveland, a committee was appointed to standardize the steps of the meter schedule, and that committee now has the matter under consideration. We remembered the work of this Association of several years ago, when standard steps were adopted, together with a standard form of meter rate. The adoption of that standard rate by this Association, has, I believe, been most helpful to the water-works business throughout the United States. The adoption of a similar standard by the American Water Works Association would be even more useful. But we do not wish to have any competing schedule set up by it. Since the schedule was adopted by this Association some years have passed, and meter rates in the adopted form have been used and experience gained with them. No doubt various points of view will be presented to the present committee, but I think the disposition of all members of the committee will be to take the New England form as a starting-point, and to modify it as little as may be. Our committee thinks that it would aid if this Association, and perhaps other water-works associations, would each appoint some one to represent it in this matter, with a view to getting every one to agree to any changes that may be desirable and to have one standard adopted for the whole country. I hope we shall have the coöperation of this Association in this important matter.

Mr. Hazen moved that the President designate some one to coöperate with the committee of the American Water Works Association, which was voted. The President appointed Mr. Arthur E. Blackmer.

THE TYPHOID FEVER EPIDEMIC AT SALEM, OHIO.

BY W. H. DITTOE.*

[*Read September 15, 1921, by* MORRIS KNOWLES.†]

The epidemic of typhoid fever which occurred at Salem, Ohio, during the fall of 1920 is of unusual interest to persons engaged in public health work. This epidemic showed one of the highest case rates ever recorded, and at the same time the mortality rate was the lowest of the important epidemics of the United States. The epidemic was caused through the medium of a public water supply which for many years had been of a high degree of purity and had never previously been held responsible for any water-borne disease.

These features of the epidemic warrant a complete relation of the circumstances surrounding it, and there is now in preparation an official report, to be issued by the State Department of Health, which will supply all details. Therefore I shall not endeavor to discuss completely all phases of this epidemic, and shall only relate the important circumstances, including a description of the water-supply system and the manner in which it became contaminated.

The city of Salem is located in Columbiana County in the northeasterly portion of Ohio, at the headquarters of Little Beaver River, a tributary of the Ohio River. The population of this city is about 10 000. It has a thriving industrial development, but its rate of growth has been rather slow. In addition to its public water-supply system the city has a system of sewerage constructed on the separate plan, and also has a number of paved streets. The sanitary sewers cover practically all of the built-up area, and serve a population of about 9 000. Sewage is delivered to a sewage-treatment plant located northwest of the city, consisting of tanks and intermittent sand filters, the effluent from which is discharged into a small creek. This plant is inadequate, and, moreover, it has been greatly overburdened, due to the misuse of the sanitary sewers. The city has neglected to control sewer connections, and as a result these connections have been established very carelessly and have permitted large volumes of surface and subsoil drainage to reach the sewers. In addition, there are several poorly constructed private sewers connected to the system. It will be shown later that the improper control of sewerage was a contributing cause to the occurrence of the epidemic.

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History of Epidemic.

During the early part of September, 1920, an outbreak of enteritis occurred in Salem, and was observed by the local physicians and the health commissioner. This outbreak was not intense, and as cases of intestinal disorders were more or less prevalent in other communities nearby no particular concern was aroused. It was thought by local physicians and health officials that the sickness was "intestinal influenza," but in the light of facts later learned the Salem cases were without doubt of a different kind and due to an entirely different cause. After partial subsidence of this outbreak, a second and much more intense outbreak of enteritis occurred, starting about September 23 and consisting of approximately 7 000 cases. Typhoid fever made its appearance about October 1, and after October 12 the typhoid fever cases increased very rapidly, the epidemic mounting to a peak on November 1. Thereafter, a rapid decline occurred. The total number of typhoid fever cases which were reported and investigated was 884, including not only the epidemic cases but those which preceded and followed the epidemic, a period of two months. The total number of deaths resulting from the epidemic was 27. Chart No. 1 illustrates graphically the course of the epidemic.

While investigations showed that the typhoid fever epidemic started about October 1, the actual existence of typhoid fever within the community was not known until October 13. In the early part of October the city health commissioner issued a public warning that the water from the public water supply should be boiled, but this warning was only based upon a policy of playing safe, and was not the result of knowledge that the water was contaminated. In fact, at that time the water supply of the city was still considered to be above suspicion owing to its previous history. The State Department of Health was called upon October 13, 1920, to investigate the enteritis outbreak, and in connection with this investigation, which was conducted by an epidemiologist of the department, the existence of a few cases of typhoid fever in the city was learned. Circumstantial evidence pointed to the public water supply as the cause for the enteritis, and accordingly a boiling notice was repeated on October 15, and request was made by the epidemiologist for an engineering investigation of the water-supply system. This was conducted as promptly as possible, and included field analyses of water samples. The results of this study are shown graphically by Plate No. II. The result of this investigation fixed the water supply conclusively as the cause of the epidemic, and accordingly disinfection of the water supply with liquid chlorine was decided upon and started October 20. It is pertinent to observe that at this time the local health department knew of only four cases of typhoid fever in the city, but as the subsequent studies demonstrated, about 100 persons were suffering from the disease at the time whose cases had either not been diagnosed or had not been reported. The disinfection of the public water supply checked the epidemic. It of course

CHART NO. 1

OHIO
STATE DEPARTMENT OF HEALTH
CHRONOLOGICAL CHART
OF
TYPHOID FEVER EPIDEMIC
AT
SALEM, OHIO.

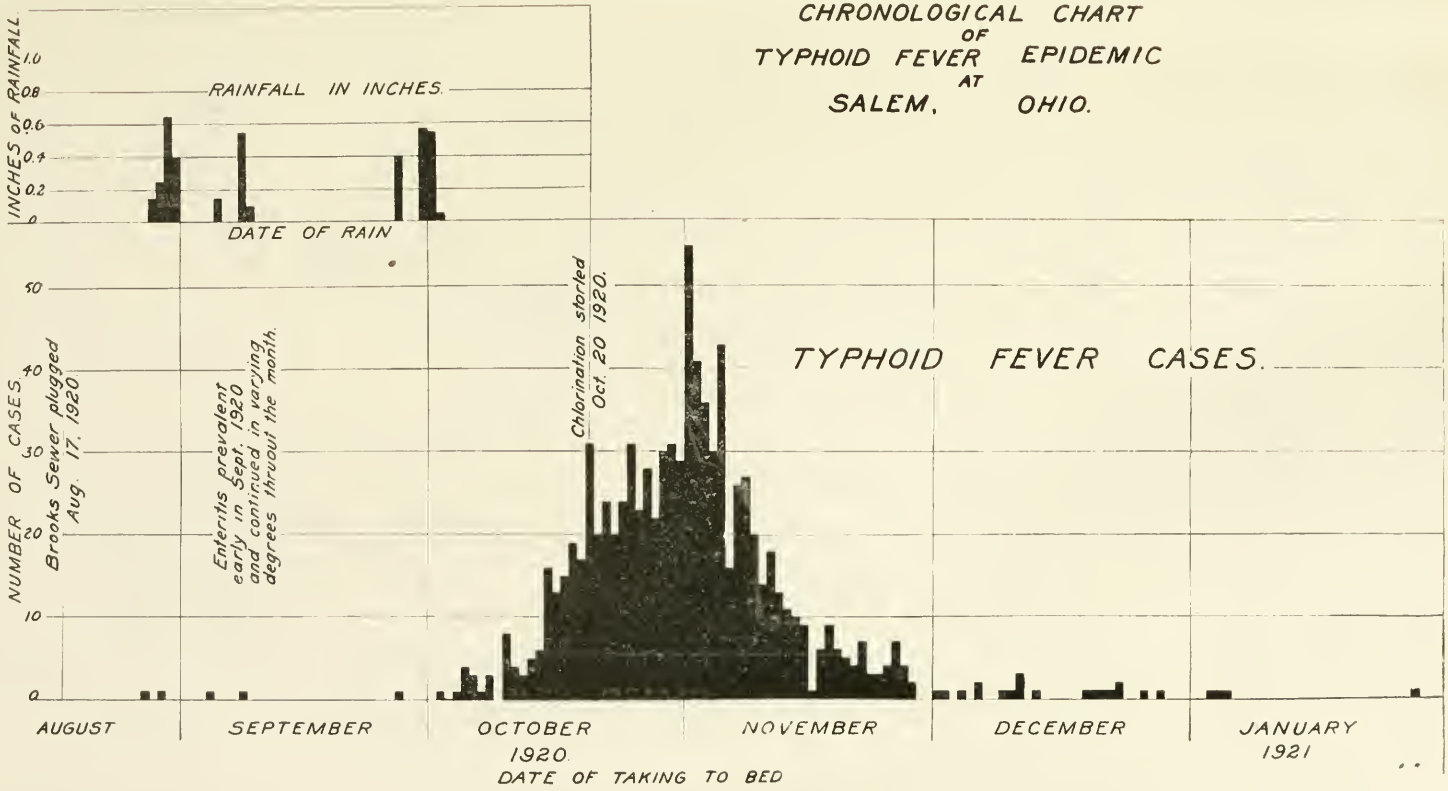
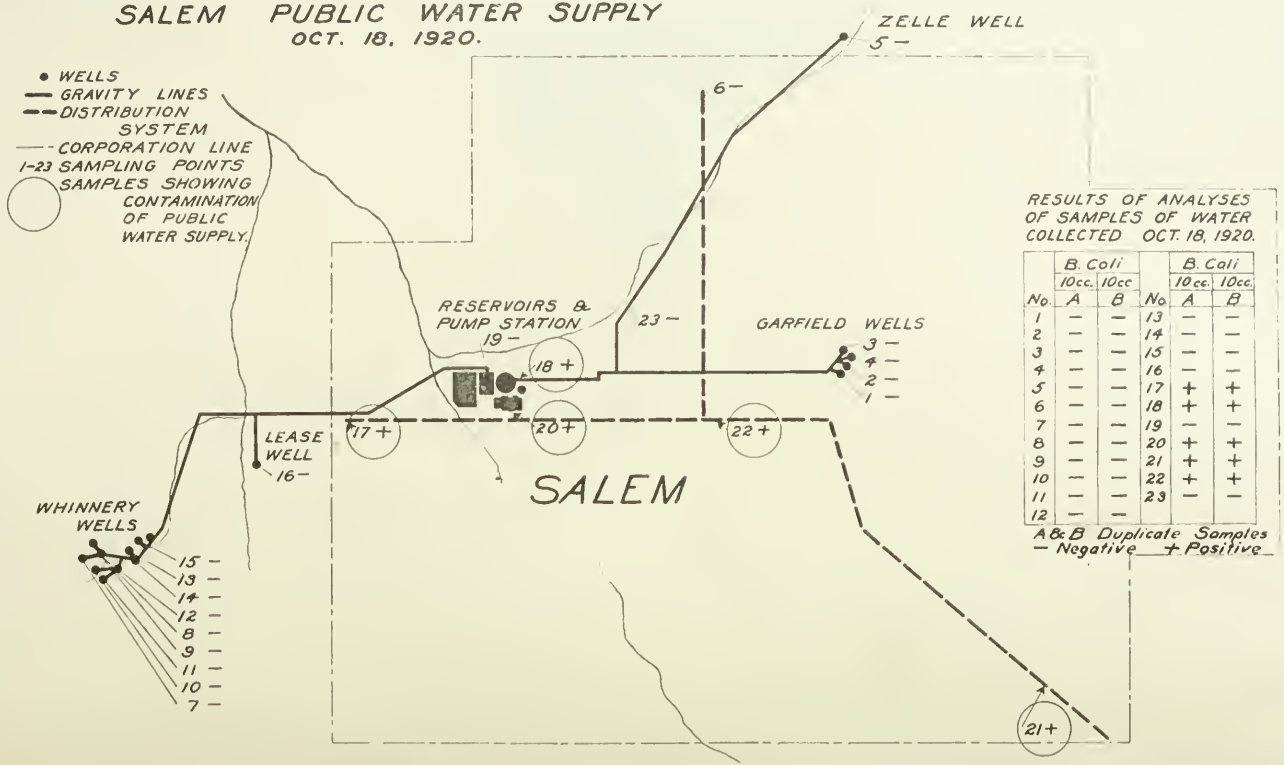


PLATE NO. II.

OHIO
STATE DEPARTMENT of HEALTH

RESULTS of BACTERIOLOGICAL INVESTIGATION SALEM PUBLIC WATER SUPPLY OCT. 18, 1920.



RESULTS OF ANALYSES OF SAMPLES OF WATER COLLECTED OCT. 18, 1920.

	B. Coli 10cc.	B. Coli 10cc.		B. Cali 10 cc.	B. Cali 10cc.
No.	A	B	No	A	B
1	—	—	13	—	—
2	—	—	14	—	—
3	—	—	15	—	—
4	—	—	16	—	—
5	—	—	17	+	+
6	—	—	18	+	+
7	—	—	19	—	—
8	—	—	20	+	+
9	—	—	21	+	+
10	—	—	22	+	+
11	—	—	23	—	—
12	—	—			

A & B Duplicate Samples
— Negative + Positive

E.I.P.

did not affect those persons who had received infection previous to October 20, but it prevented further infection, and subsidence of the epidemic occurred on schedule time. The size of the epidemic was not realized until the early part of November, when reports of cases multiplied, and on November 9, at the request of the city officials, the State Department of Health assumed charge of the local situation and sent representatives to make a thorough investigation and apply necessary remedial measures to prevent the spread of the disease.

Sanitary Investigation.

When the representatives of the State Department of Health undertook the investigation on November 9, practically no accurate information regarding the epidemic was available except the knowledge that the public water supply had been the medium of infection, and that by instituting chlorination on October 20, this cause of the disease had been removed. It became necessary, therefore, to institute a careful inquiry regarding the situation throughout the city, and for this purpose what has been termed a sanitary investigation was made. This comprised a visit to each occupied building within the city and in the built-up district surrounding the city, a total of 2 630 places. Information was obtained regarding cases of illness, and the nature of the same, occurring after September 1; the source of the water supply used prior to illness; the existence of a water-service connection, a private well or other private source of supply, and the existence of a sewer connection, privy or cesspool. In addition, printed notices were left at each place, containing a warning to boil all water used for drinking, and giving instructions regarding disinfection of stools from typhoid fever patients. This sanitary investigation would not have been possible had it not been for the earnest effort of the local War Workers Organization. By the united effort of the members of this organization, the sanitary investigation was practically completed during a period of twenty-four hours, making the information promptly available. The results of this sanitary investigation gave information which was the basis upon which the epidemiological investigation was made and the various remedial measures were applied to check the spread of the disease.

Epidemiological Investigation.

Starting on November 9 and continuing until the epidemic had subsided, a careful and thorough epidemiological investigation was made of each case. The usual information regarding each case was secured, consisting of the date of first symptoms, the date taken to bed, the location of the case, the sex, age and color, and an inquiry to determine the possible exposure factors during the period when the disease was contracted. These factors include the milk supply, the food supply, the water supply, the attendance at public gatherings, and the opportunity for contact infection.

I shall not endeavor to present any details of the results of the epidemiological investigation. All sources of infection were clearly eliminated except the public water supply of the city, which was found to be the common factor. The chronology, distribution, and general character of the epidemic also pointed to the public water supply as the cause. Therefore the evidence established the epidemiological diagnosis "that the contamination of the public water supply was the cause of the epidemic."

Description of Water Supply.

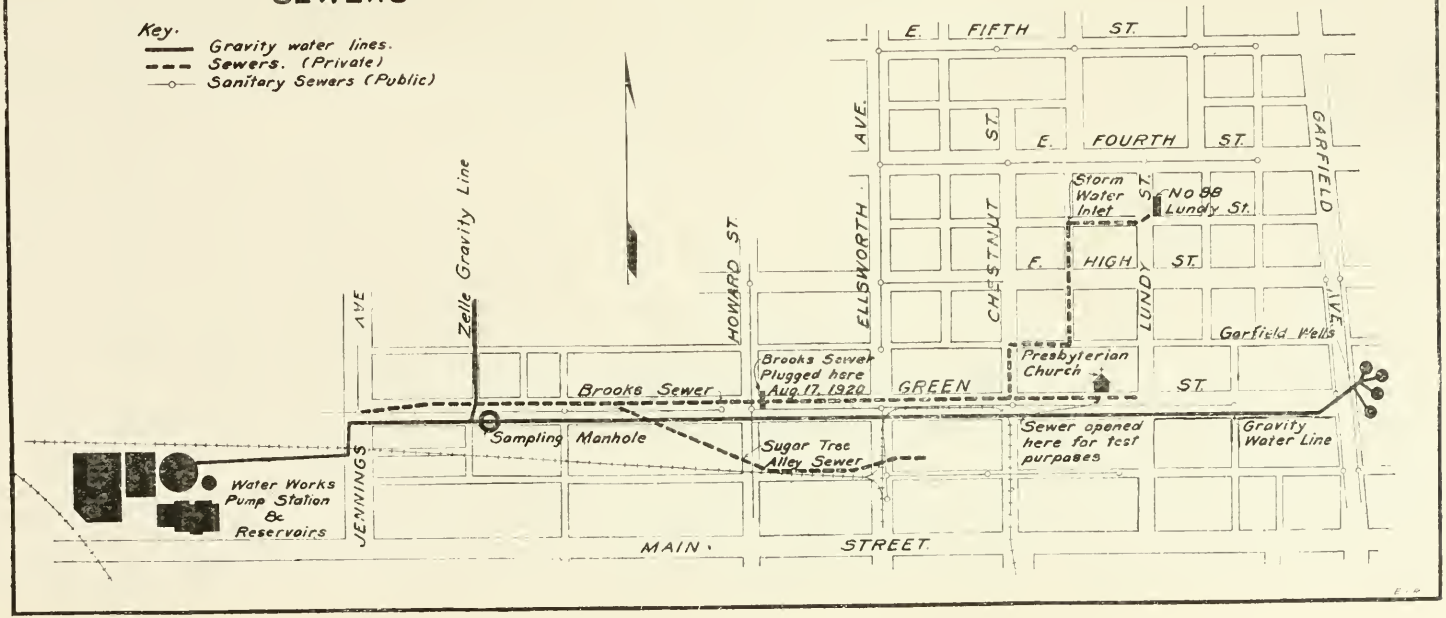
The following description of the public water supply system of Salem applies to the system as it existed prior to the epidemic, and does not include the changes or improvements made subsequently. The Salem Water Company started the development of the present system in 1887, continuing its ownership until 1899, when the Salem Water Works Company succeeded to ownership. In 1909, the system became the property of the city. The water supply is obtained from four general sources, as follows: The Garfield Avenue wells, located immediately northeast of the central portion of the city; the Whinnery wells, located approximately one-half mile west of the city; the Lease well, located approximately one-quarter mile west of the city, and the Zelle well, located immediately north of the city. The water is lifted from the various wells either by air-lift or deep well pumps, and delivered by gravity lines to storage reservoirs located near the main pumping station in the westerly portion of the city, and from these reservoirs the supply is pumped to the distributing system. The general locations are shown by Plate No. II.

The Garfield Avenue wells are very poorly located, being on a tract of land occupied by a high-school building and in a district which is entirely built up with residences, many of which are accompanied by privies and abandoned private wells. There are also sewers and other contaminating influences near the wells. Wells were developed at this site as early as 1882, before the water company assumed control, and these were continued in use until 1898, when additional wells were drilled and the old wells deepened. At this time the water was pumped from the wells directly into the distributing system, but in 1900 air-lift equipment was installed to pump the wells, and a gravity line was constructed extending from the site of the wells to the reservoirs at the main pumping station. The wells have been operated in this manner since 1900. The Garfield Avenue wells are 265 ft. in depth, penetrating 12 ft. of clay, 100 ft. of brown sandstone, 80 ft. of fire-clay or soapstone, and extending the rest of the way through white sandstone. The casings of the wells extend to a depth of about 100 ft., and the water is mainly derived from the white sandstone. The gravity line has a total length of 3 400 ft. and is constructed of 12-in. vitrified, salt-glazed, double-strength sewer pipe in 3-ft. lengths, with deep and wide sockets. Joints were made with cement. The line extends in Green Street and Jennings Avenue, both of which are almost completely built up, and there

PLATE NO. III

OHIO
STATE DEPARTMENT OF HEALTH

GENERAL PLAN
OF
GREEN ST. & VICINITY
SHOWING LOCATION OF
WATER WORKS, GRAVITY LINE
AND
SEWERS



are numerous sources of contamination of the shallow ground water along the route of the line. Private and public sanitary sewers parallel and cross the line and are at points at elevations higher than that of the gravity line. The location of the gravity line is shown by Plate No. III. The Garfield well development is unsatisfactory on account of the unfavorable location of the wells themselves, and also on account of the use of a gravity line which subjects the water to dangerous contamination. While these conditions were recognized to be potentially dangerous they had not caused trouble prior to the epidemic. Samples from the wells collected at various times during the past twenty years have given satisfactory results, and this is true also of samples collected from the reservoirs receiving the discharge from the gravity line.

In 1903 it became necessary to increase the water supply, and the Salem Water Works Company started the development of the Whinnery wells at a point about one-half mile west of the city. The original installation comprised six wells, and five additional wells have been installed from time to time since 1903. The site of the wells is satisfactory. The surrounding country is open farm land and there are no nearby sources of contamination. The wells are 180 ft. to 200 ft. in depth, penetrating 85 ft. of clay, 80 ft. of white sandstone, a few feet of limestone and a stratum of black slate. The supply is obtained from the white sandstone formation. Four of the wells are pumped by deep well pumps, and six of them are pumped by air-lift. The water is discharged into a gravity line which extends a distance of some 5 700 ft. in an easterly direction, to the reservoirs at the main pumping station. This gravity line is well constructed of 10-in. cast-iron pipe with leaded joints, and is probably water-tight. The fittings at the tops of the casings of the wells equipped with deep well pumps are apparently tight. Brick cisterns with plank covers are placed around the tops of the wells pumped by air-lift. The covers are not securely fastened and are not tight, and the cisterns in general have been permitted to deteriorate so that the water as discharged from the wells is exposed to possible contamination. This is the only unfavorable sanitary feature of the Whinnery well development. Samples from the Whinnery wells have always shown this supply to be of excellent sanitary quality.

The Lease well, which is located about one-quarter mile west of the city, between the Whinnery wells and the city, was developed in 1914 and is similar to the Whinnery wells. It is pumped by air-lift and is provided with a brick cistern. The same comment made in regard to cisterns at the Whinnery wells applies to this development. Samples from the Lease well have always shown freedom from contamination.

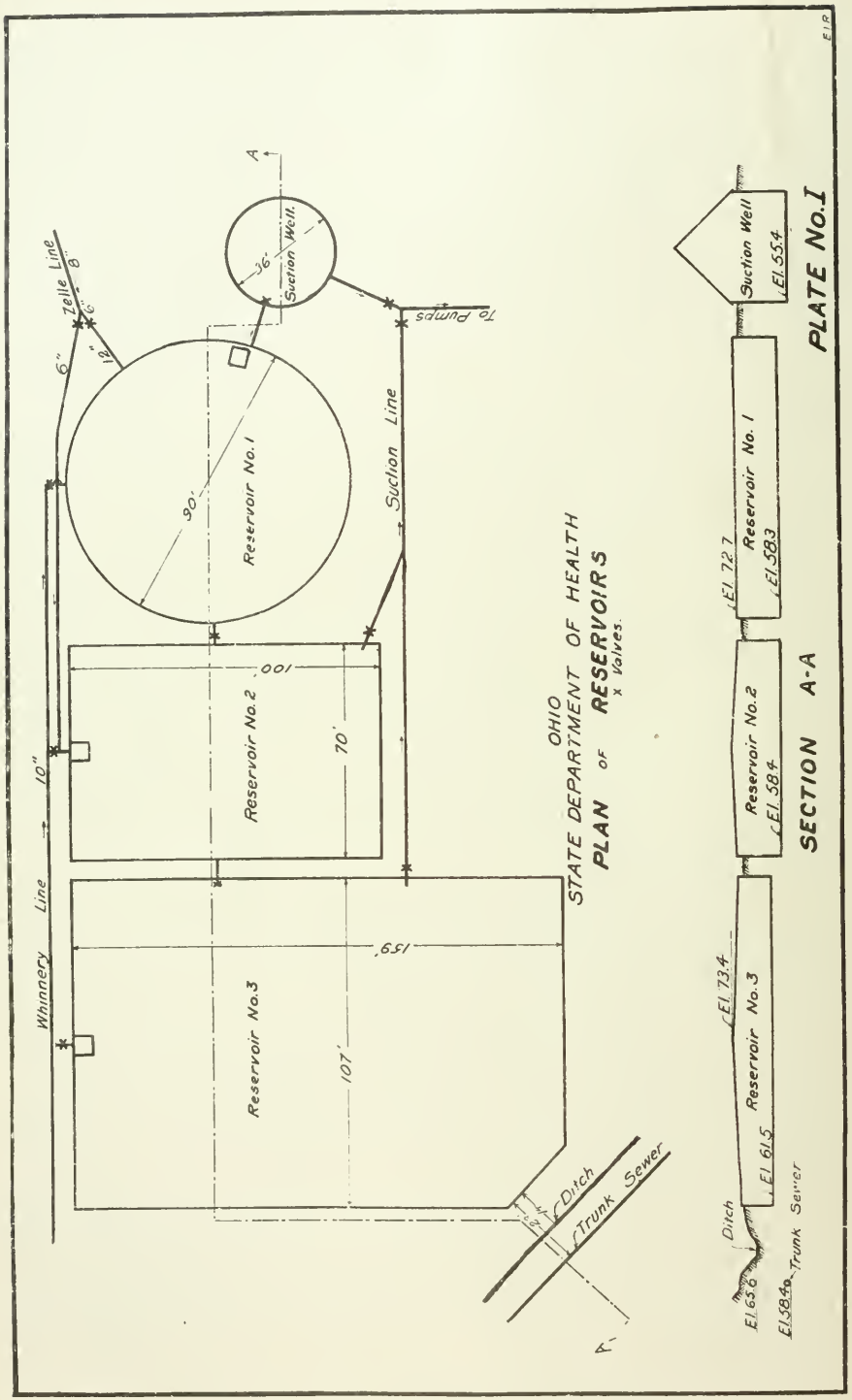
During 1916, the city increased the available water supply by drilling wells on the Zelle Farm, located immediately north of the city. The location of these wells is satisfactory and the city owns a 24-acre farm at this point. Only one well is now in service. This is approximately 180 ft. in depth and penetrates 35 ft. of sand and gravel, 5 ft. of shale, an unknown

thickness of brown sandstone, and an underlying soapstone formation. The well is plugged at a depth of 165 ft. The water is obtained from the brown sandstone formation. The well is pumped by direct suction, the water being discharged into a gravity line constructed of 6-in. cast-iron pipe with leaded joints and extending from the well site in a general southwesterly direction to a connection with the old vitrified pipe gravity line serving the Garfield Avenue wells. From this point the combined flow of the Garfield Avenue wells and the Zelle well is conveyed in the vitrified pipe line to the reservoirs at the pumping station. The tops of the wells at the Zelle Farm are not securely closed to prevent entrance of chance contamination, but otherwise the well development is satisfactory. The gravity line is poorly located, as it extends along the banks of a small stream and is, therefore, subject to washout. Evidence also indicates that the joints of this line were not made properly and that many of them are leaky.

The water from the various sources of water supply delivered through the gravity lines is received in storage reservoirs constructed at various times between 1887 and 1917. These comprise Reservoir No. 1, a circular structure 91 ft. in diameter and 12 ft. in depth, with a stone wall and a concrete bottom and cover; Reservoir No. 2, a rectangular structure 100 ft. by 70 ft. in plan and 14 ft. deep, with concrete floor, walls and cover, and Reservoir No. 3, a rectangular structure 159 ft. by 107 ft. in plan and 10 ft. deep, with concrete floor, walls and cover. In addition, there is a pump well 36 ft. in diameter and 16 ft. deep, with a concrete floor, brick walls, and timber cover from which the pump suction is normally taken. The reservoirs are so connected that water may be discharged into either Reservoir No. 1 or No. 2, and may be drawn to the pumps from the suction well or from Reservoir No. 2 or No. 3. The general arrangement of the reservoirs is shown on Plate No. I.

The condition of the reservoirs and suction well is not satisfactory. The bottoms of all the reservoirs are in a leaky condition and the walls of Reservoirs No. 2 and No. 3 and of the pump well are also leaky. This permits the entrance of shallow ground water into the reservoirs when the water within them is lowered to an elevation below that of the surrounding ground water. This is of particular importance when it is known that the reservoirs are located at about the lowest elevation within the city, to which vicinity practically all of the natural and artificial drainage is directed. The main trunk sanitary sewer of the city passes Reservoir No. 3 at a distance 23 ft. from its west wall.

The water supply is in general use by the citizens of the city, and prior to the epidemic was popularly accepted as a pure supply. It is also made available to the industrial plants of the city which generally maintain private supplies obtained from wells similar to those of the city. Careful investigation revealed existence of a number of cross-connections with the public supply.


OHIO
STATE DEPARTMENT OF HEALTH
PLAN OF RESERVOIRS
X Valves.
Reservoir No. 1
Reservoir No. 2
Reservoir No. 3
Suction Well
Suction Line
To Pumps
Zelle Line
Whinnery Line
Ditch
Trunk Sewer
SECTION A-A
Reservoir No. 1
El. 583
El. 727
Reservoir No. 2
El. 584
Reservoir No. 3
El. 615
El. 734
Suction Well
El. 554
Ditch
El. 630
Trunk Sewer
El. 384
PLATE No. I

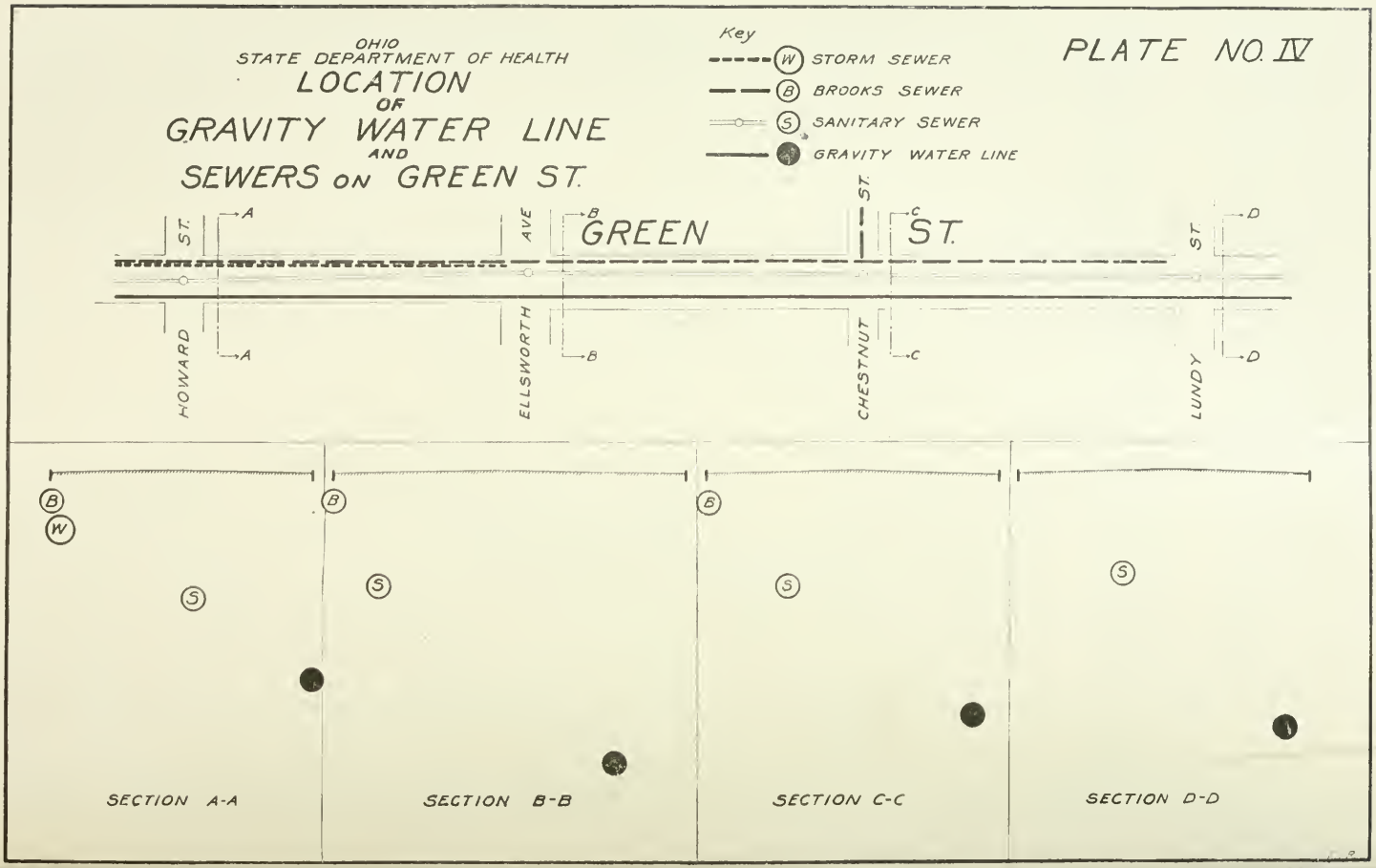
Summarizing the above description of the water supply system of the city, it will be noted that while the water had for a number of years been considered safe, due to favorable analyses and absence of outbreaks of water-borne disease, there existed at the time of the epidemic a number of defects in the development of the system. For convenience these will be repeated as follows:

1. The location of the Garfield wells is unsafe.
2. The gravity line serving the Garfield Avenue wells is of unsafe construction, probably not water-tight, and as it passes through the built-up portion of the city the water supply is thus rendered subject to contamination.
3. The tops of the various wells are not securely closed.
4. The iron pipe gravity line serving the Zelle well is poorly located and has poorly leaded joints.
5. The reservoirs have leaky walls and bottoms, subjecting the water supply to danger of contamination by shallow ground water.
6. Connections to the water-works mains exist, whereby private water supplies may reach the distributing system.
7. While not directly connected with the sanitary safety of the water supply, mention must be made of the inadequacy of the supply, which has caused several severe shortages during recent years.

Manner in Which the Water Supply became Contaminated.

Recognizing the various defects of the water-works system, it became necessary to determine beyond reasonable doubt the manner in which the public water supply became contaminated and thus caused the epidemic of typhoid fever. The investigations and studies of this matter required much time and painstaking care, and obviously consideration of each defect was demanded. The first investigation, made October 18 and 19, including bacteriological examination of samples, indicated that the contamination was reaching the water supply through the vitrified pipe gravity line serving the Garfield Avenue wells, and these results warranted the presumption that this was the cause of the epidemic. Plate No. II shows these results. Accordingly, in addition to chlorinating the water supply, beginning October 20, the use of this gravity line for the Garfield Avenue wells was terminated October 27, as soon as pumping equipment could be installed and the water delivered directly into the distributing system. It was necessary to continue the use of the power portion of the vitrified pipe gravity line for conveying the water from the Zelle well until December 3, when a new cast-iron line was completed. A careful consideration of the various defects of the water-works system finally eliminated all possible causes of contamination except the vitrified pipe gravity line. Taking up each of the defects, it may be advantageous to indicate how they were eliminated.

The possibility of deliberate or accidental contamination of the water supply through the tops of the well casings cannot be eliminated definitely, but this does not appear as a probability, particularly in view of the fact


OHIO
STATE DEPARTMENT OF HEALTH
LOCATION
OF
GRAVITY WATER LINE
AND
SEWERS ON GREEN ST.
PLATE NO. IV
Key
W STORM SEWER
B BROOKS SEWER
S SANITARY SEWER
GRAVITY WATER LINE
GREEN ST.
HOWARD ST.
ELLSWORTH AVE
CHESTNUT ST.
LUNDY ST.
A
B
C
D
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D

that the history of the epidemic indicates that the water supply was infected on more than one occasion during the time the outbreak was developing.

Direct contamination of the Garfield Avenue wells probably did not occur, as samples collected from them for a long period of years prior to the epidemic and during the period of investigation after the epidemic started did not show contamination.

The cast-iron pipe gravity line serving the Zelle well under certain circumstances might have admitted contamination through a leaky joint, but this possibility is removed by the evidence that the line was under internal pressure continuously from the spring of 1920 until October, 1920, at points where it would be possible for contamination to reach the line. Furthermore, analyses of samples from this line failed to show contamination.

The cross-connections on the distributing system, permitting discharge of water from private industrial water supplies, are not held accountable, due to the fact that these supplies are generally of the same character as the deep well supplies of the city, and, furthermore, the distribution of cases throughout the city would not correspond with contamination in this manner.

In spite of the unsatisfactory construction of the reservoirs and pump well at the main pumping station, a careful investigation produced evidence showing that these structures were not responsible for the typhoid fever outbreak. Evidence was obtained showing that at no time during the summer of 1920 did the level of water in the reservoirs fall below that of the shallow ground water surrounding them. A test was conducted to determine whether it would be possible for sewage to pass from the main sanitary trunk sewer of the city to Reservoir No. 3. This was done by plugging the sewer so as to place it under a head of 6 ft., adding at the same time to the sewage a considerable quantity of uranine, which is a very intense green dye. Previously, Reservoir No. 3 had been completely emptied, and it was noted shallow ground water seepage entered through the walls and bottom. This condition was permitted to continue for slightly more than one hour, and samples of the seepage reaching the reservoir were regularly collected, but failed to show evidence of the uranine color.

The study of the vitrified pipe gravity line serving the Garfield Avenue wells gave conclusive results that the water supply was contaminated by leakage of sewage into this line. This line extends in Green Street and is paralleled by a sanitary sewer, a storm sewer and two private sewers. One of these private sewers, known as the Brooks sewer, was installed a number of years ago for private use, but was later connected to the sanitary sewer system of the city and was continued in use as a combined sewer. Not only did it receive sewage from a number of residences and a church, but it also received the surface run-off from a built-up area of several acres, this reaching the sewer through a catch basin near its upper end. The Brooks sewer was constructed with open joints, and the pipe was without bell ends.

It, therefore, must have been leaky. A storm sewer paralleling it had discharged sewage for several years, and a nuisance had been created at the outlet. This sewage was probably reaching the storm sewer by seepage from the Brooks sewer. An effort was made by the employees of the city to correct these conditions, but it was impossible to discover what dwellings were connected to the Brooks sewer. Therefore, on August 17, 1920, a plug was inserted in the Brooks sewer, at Howard and Green streets, by employees of the city, with the thought in mind that sewage would back up in this sewer and flood cellars of dwellings connected to it, thus bringing about complaints which would expose the existence of connections to the sewer. However, no complaints arose, and apparently the sewage continued to leave the Brooks sewer through the open joints without backing up sufficiently to flood cellars. With these conditions existing, heavy rainfall occurred during the last four days of August, 1920. This was followed by an outbreak of enteritis. Other heavy rains occurred September 9, September 27, September 30, and October 1, and apparently were the forerunners of the typhoid fever epidemic.

While all of the evidence strongly pointed to soundness of the belief that the Brooks sewer and the gravity line were the causes of the epidemic, it appeared necessary to prove the possibility of passage of sewage from the Brooks sewer to the gravity line. In an effort to do this, a sampling manhole was placed on the gravity line near its lower end, where the seepage leaving it could be observed, sampled and measured. It was soon found that the seepage was contaminated ground water, and that the rate of flow was influenced by rainfall. A concentrated salt solution was introduced into the Brooks sewer above the plug, and at the same time the Brooks sewer was filled with water from a fire hose to imitate surcharging such as would be caused by rainfall. Careful examination of samples from the gravity line showed an appreciable increase in the chlorine content, 30 parts per million being present before the test and 46 parts per million after the salt was applied. This was not considered to be sufficiently conclusive, and further tests were made using uranine. This was applied at the storm-water inlet to the Brooks sewer, at the same time filling the sewer with water from a fire hose. Within two hours after this dye was applied at the storm-water inlet, a definitely noticeable green discoloration appeared in the seepage from the gravity line at the sampling manhole. Allowing for the time for flow in the Brooks sewer and in the gravity line between the storm-water inlet and the sampling manhole, the time for transfer from the Brooks sewer to the gravity line could not have exceeded thirty minutes. These investigations established conclusive evidence that the typhoid epidemic at Salem was caused by the passage of sewage from the Brooks sewer to the gravity line. Important confirming evidence is furnished by the fact that about October 1 there was a case of typhoid fever in a dwelling connected to the Brooks sewer, the stools from which were flushed directly into this sewer.

Measures Taken to Control the Epidemic.

The placing in operation on October 20 of a disinfection plant to treat the public water supply of the city at the main pumping station effectually checked the epidemic. This was the most important step taken to prevent the continued spread of the disease. Added safety was secured by abandoning the use of the vitrified pipe gravity line for delivery of water from the Garfield Avenue wells on October 27, and by the reconstruction of the lower end of this line, using cast-iron pipe which was placed in service for the delivery of water from the Zelle well on December 3. An added measure of safety was provided by placing in operation on December 11 a liquid chlorine machine to treat the water pumped from the Garfield Avenue wells into the mains. Daily analyses of the water as delivered to the consumers indicated that after the disinfection of the supply was started the water was safe for drinking purposes at all times.

Owing to the intensity of the epidemic, however, and particularly recognizing the results of the sanitary investigation, it was deemed advisable to place in effect other measures to prevent the spread of typhoid fever. The sanitary investigation revealed the existence of some 276 private dug wells, 127 private drilled wells, and many cisterns throughout the city. The majority of these wells and cisterns were old and unused prior to the epidemic, but owing to the suspicion which was aroused regarding the public water supply the people generally turned to private sources of drinking-water supply. Accordingly, it was felt that some definite measures should be taken to protect the inhabitants of the city from disease which might arise from the use of such private supplies, as such supplies were in constant danger of contamination by the discharges of typhoid fever patients. Public warnings were given against the use of dug wells and springs, and, in addition, 100 dug wells and 37 cisterns were disinfected by applying to each one pound of hypochlorite of lime. This effectually prevented the use of such wells.

The sanitary investigation revealed the existence of 441 privies, the most of which were of improper construction. As it was thought that many of these had been used by persons suffering from typhoid fever infection it was deemed advisable to attempt disinfection of these privies. Accordingly, each privy vault in the city was treated with approximately five pounds of hypochlorite of lime.

Particular emphasis was placed upon the disinfection of stools from typhoid fever patients, and to facilitate this a supply of hypochlorite of lime in 1-lb. tins was secured by the city and distributed without cost to families in which cases of typhoid fever existed.

It was not known what effect the sewage from the city might have upon the population downstream from Salem, and it was deemed justifiable to attempt disinfection of the sewage at the sewage treatment plant. For this purpose, a dry feed chlorine gas machine was installed to treat the

settled sewage. The amount of chlorine applied was approximately five parts per million, which was the maximum capacity of the machine. No bacterial results are available to show the efficiency of this treatment. On the Ohio River below the mouth of Little Beaver River are several communities in Ohio and West Virginia obtaining their public water supplies from the stream. Each of these communities was notified of the existence of the typhoid fever epidemic in order that they might take precautions in the treatment of their water supplies.

Pasteurization of the entire milk supply of the city was effected. Fortunately, a large milk depot had been established at Salem and was equipped with efficient pasteurizing machines, making possible the treatment of the entire milk supply of the city. Regulations were also enforced prohibiting the leaving of milk containers at premises where typhoid fever existed, and prohibiting delivery of containers to purchasers at groceries and other places selling milk. These measures continued in effect until the epidemic had subsided.

Prevention of the spread of the disease through contact is attributable to the efficient public health and private duty nursing service which was provided. Over 300 nurses responded to the general call for help, and as a result every patient in the city received daily nursing attention. Too much credit cannot be given to the nursing service for the prevention of the spread of the disease through contact and for the low mortality rate.

Inoculation was generally taken advantage of by the people. It is estimated that at least 4 000 persons were inoculated. These included all of the food handlers of the city.

Unusual medical service attended the treatment of this epidemic. The seventeen local physicians were assisted by three volunteer physicians from neighboring cities and six consultants. Dr. Henry A. Christian of Boston, Mass., did most to accomplish the proper treatment of the cases, to which must be attributed in a large measure the low mortality rate. Hospital facilities included five hospitals, four of which were improvised. The total capacity, 180 beds, was taxed during the peak of the epidemic.

Recommendations Made to Prevent a Recurrence of the Epidemic.

The outstanding recommendations made by the State Department of Health to the city officials to prevent possibility of a recurrence of the typhoid fever epidemic relate to improvement of the public water-supply system. The following were the principal items of advice regarding the water supply:

1. To continue chlorination of the water supply until improvements in the system could be made which would insure a safe water supply at all times.

2. To provide extensive improvements of the water-supply system to insure an adequate water supply of good quality, and pending the completion of such improvements to take the following steps:

3. To abandon permanently the Garfield Avenue wells, requiring increase of the other sources of water supply.

4. To abandon permanently the vitrified pipe gravity line. This has been done.

5. To repair the cast-iron pipe gravity line serving the Zelle well field.

6. To protect all wells from contamination by securely closing the tops of casings.

7. To abandon or make water-tight the storage reservoirs at the main pumping station.

8. To require abandonment of unsafe private wells.

The foregoing recommendations have not been fully carried out to date, but the city has learned its lesson and is taking steps to follow these recommendations fully.

In addition, recommendations were made to the city that legislation be passed providing for the proper control of the use of the sewers of the city in order to secure the use of the same in accordance with the purposes for which they were designed. Progress has been made looking toward the carrying out of these recommendations.

In order to provide proper control of the milk supply, sanitary inspection of dairies by the city was recommended and continued pasteurization of the milk supply to the city until the epidemic had entirely subsided.

Lessons Learned from the Epidemic.

While the epidemic involved a great loss in life, money, and efficiency, it produced facts the recognition of which will prevent the occurrence of other epidemics of similar cause. The outstanding fact is the necessity of proper construction and maintenance of public water-supply systems. No city can afford to overlook this fact. All features of construction and maintenance of the water-supply system must be of highest standard to insure continuous safety. Another lesson learned is the necessity of analysis of the public water supply at regular intervals, regardless of its reputed quality. Had these lessons been learned and followed at Salem prior to the epidemic, it is safe to say that the epidemic never would have occurred.

As a result of the Salem experience, the General Assembly of Ohio in 1921 passed a law intended to provide better control of public water supplies in Ohio. This law contains the following principal features:

1. It gives the State Department of Health general supervisory control of all public water supplies.

2. It requires the municipality or owner of the system to have analyses made regularly.

3. It prohibits dangerous emergency supplies and cross-connections between public and private water-supply systems.

4. It empowers the State Department of Health to require changes and improvements in public water-supply systems to insure safety.

It is believed that the proper enforcement of this law will accomplish much in the prevention of water-borne typhoid fever in Ohio.

Discussion.

Mr. J. W. Ledoux.* There is one feature which seems to be very impressive, and that consists in laying a low-pressure water-supply pipe parallel to and close by a sewer which may be acting at a higher head. Even if this water pipe had been of cast iron and laid in the best manner possible, joint and other leaks are liable to subsequently exist, and with a terra-cotta pipe leakage was sure to exist, because there is not one man in a hundred who can be depended on to lay a terra-cotta pipe water-tight. In case of leakage, the sewage was sure to get into the pipe. The remedy would be either to design the system so that the water pipe would be under higher pressure than in the sewer or else to change the location entirely. The serious feature seems, to me, should have been anticipated in the beginning.

Mr. Knowles. There is no doubt it could have been, and I agree with you that it should have been anticipated. It is undoubtedly true that typhoid fever usually comes from things which could have been prevented. This was a tile pipe line which had open joints, and the sewer had open joints. Of course the thing could have been prevented by having tight lines or a pump with greater pressure so that the water would have gone out. Analysis would have told them there was danger, and they ought to have had continued analyses all the time. They trusted to the fact that the supply had had a good reputation for years.

Mr. Frederic I. Winslow† (*by letter*). The paper of Mr. W. H. Dittoe, read by Mr. Morris Knowles at Bridgeport, is one of remarkable interest. It seems very much like the system in vogue in the old days in New England homesteads, where the privy and the well were placed side by side for general convenience. It is also not wholly unlike the case in England many years ago, where hop-pickers, brought down to the fields from London to gather the crop, camped on the soil, which happened to be marked by many crevices. The campers used the ground freely, with the result that the discharges found their way into a neighboring water supply and an epidemic of typhoid was the result. In the Salem case there appears to have been either culpable negligence or gross ignorance in the

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laying of the sewer and water pipes, when they must have been known to have been in close proximity; aside from the policy of collecting water for drinking purposes from a district where sewers existed in plenty. Incidentally, this case emphasizes the necessity and difficulty of maintaining a water supply without contamination, and a case came in the writer's experience some years ago where a mild epidemic of typhoid attacked various sections of a town deriving its water supply from driven wells. The cause of the outbreak was never definitely ascertained; but a few years after the epidemic the writer found a connection into the fire piping of a large factory from a foul stream, and it transpired that a fire had occurred in this place at about the time of the epidemic, making it at least extremely probable that the connection was the cause of the trouble. It seems impossible that no one in the town of some intelligence knew of this possible danger and through lack of courage or energy did not like to make it known.

SOME OBSERVATIONS CONCERNING WATER-SUPPLY MAINS.

BY J. W. LEDOUX.*

The selection of the size and character of pipe or conduit is an important duty of the designer of a water-works system.

When there are required sizes 24 in. and upwards and pressures over 50 lb. per square inch, where strict economy and satisfactory results are essential, a consideration of the various types of pipe obtainable is advisable.

Some conservative designers would decide the matter offhand in favor of ordinary cast-iron pipe, which they estimate to be so far superior to all other types in all practical essentials as to leave no room for argument.

In a large part of the United States, especially in the districts yielding limestone or hard waters, where the soil conditions are favorable, this position could not be seriously criticized, because the initial leakage should be immaterial, the cost of maintenance nominal, the lasting quality indefinite, and cast-iron pipe can be obtained readily in the competitive market throughout the East and Middle West.

For the soft waters of New England and other states, the mountain regions and the colored waters of the Atlantic Coast, cast-iron pipe is under a disadvantage, and supply mains will lose a large portion of their carrying capacity within a very few years. Instances of small sizes losing 60 per cent. and large sizes 30 per cent. of their original capacity within twenty years are common. It is true the pipe can be cleaned and the original discharging capacity restored, but the effects of such cleaning seldom last long, so that in a short time, sometimes within a year after cleaning, the results are as bad as before, so to maintain the flow the cleaning has to be repeated frequently.

Where the pipe has been designed with a large over-capacity, little trouble is noticeable to the water-works owners, who seldom investigate until they are in trouble, when an additional main is installed, which might have been postponed indefinitely if the pipe had retained its original capacity

It is remarkable what a large reduction in discharge capacity tubercles will cause without materially reducing the internal volume of the pipe. In one case a 4-in. cast-iron pipe was tested in service and found to have a coefficient of 26 per cent. A typical section was taken out and its volume determined by filling with water. The tubercles, which were soft, were then cleaned out and the pipe again filled with water; when it was found

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the tubercles had occupied only $3\frac{1}{2}$ per cent. of the internal volume, and yet their roughness had the effect of reducing the pipe's discharge capacity by 74 per cent. which was later proved by cleaning a thousand feet of the pipe, when the coefficient was restored to 100 per cent.

While there are other objections to cast-iron pipe, such as liability to electrolysis, inability to resist the corrosive effects of acid soil found in the coal mining regions and in cinder banks along the railways, these are insignificant when compared with the reduction in carrying capacity.

If a 16-in. pipe is good for 3 000 000 gal. per day, and its capacity is reduced by 20 per cent. and water is worth 5 cents per 1 000 gal., there is a theoretical loss of $30 per day, or over $10 000 per year.

While water-works engineers have for many years recognized this vital defect of cast-iron pipe, the knowledge is now becoming so widespread that many minds are casting about for a substitute that will retain its carrying capacity; and it is to be hoped that in the near future a material will be found that will combine all the virtues of cast iron, but will not rust or tuberculate. In fact, it has been alleged that such an iron or metal alloy can now be produced at commercially permissible prices.

It is sometimes held that success can be attained by a suitable coating or paint, but these have all been tried without permanent success. Copper, tin, lead or zinc lining offers better possibilities of success, but they are expensive. Cement lining is undoubtedly a certain protection, but it is expensive and has to be applied of such thickness as to materially reduce the discharging capacity. There is also an apparent difficulty due to the inability to make the inner lining continuous; but it is believed that material corrosion or tuberculation of the iron will not take place in the dead spaces separating the ends of the cement lining.

Cement lining has its best application in connection with wrought-iron or steel pipe, as has been proved by over thirty years' experience on a scale large enough to be conclusive. The only difficulties were with the joints, the tapping, and the competition with cast-iron pipe. But this kind of pipe became discredited, due to certain pipe contractors who tried to reduce the cost by cheap workmanship and the use of lean mortar.

For low head and large sizes, reinforced concrete is practical and successful, particularly since good and economical expansion joints have been designed. For high heads, it will in all probability be necessary to use a thin sheet-steel tube within the reinforced concrete.

Some firms are now ready to furnish, install, and guarantee this class of pipe for mostly any conditions and pressure. It has the great advantage that it can be fabricated complete in large quantities at or near the site of the installation, which is impracticable with any form of metal pipe.

Wood pipe has for many years been exploited and used as a substitute for cast-iron pipe. Where the material, design, and construction have been good and the conditions suitable, these pipe installations have been satisfactory for pressures below 150 lb. per square inch.

However, many mistakes have been made, — sometimes through undue zeal to secure a contract, but generally due to ignorance and lack of skill, which seem to be a frequent accompaniment of this line of activity.

There are two distinct types of wood-stave pipe, — the factory-made and the continuous. The former also varies in form of joint and in steel reinforcement; the commercial type being machine spirally banded with mortise and tenon joints. Another type is a machine spirally wire wound, and still another form, where the steel reinforcement consists of independent rods and malleable cast-iron lugs. The wood staves vary from $1\frac{1}{2}$ to 3 in. thick, $1\frac{7}{8}$ in. being the most common thickness.

With the continuous wood-stave pipe the staves are usually of less thickness, but independent rods and lugs are universally used. In any case the use of a soft wood is imperative, and preferably a wood containing no knots or other imperfections. Clear white pine, Norway pine, redwood and fir are the woods that should always be used, but occasionally some unscrupulous contractor tries scrub, or sap pine, with eventually bad results.

In a continuous wood-stave pipe, the staves of the proper quality and shape, the metal strips, and the independent rods and lugs are sent from the factory to the ground and there put together by men experienced and skillful in this line of construction. The iron hoops are properly spaced for the pressure, and are screwed together and made tight on the pipe by screwing up by hand operation. The material coming on the ground in that form readily lends itself to thorough inspection, and in this respect the pipe has the advantage over the factory-made pipe, which is all fabricated complete, except the end joints, but in the continuous pipe the tension on the rods depends on the uniform skill of the workmen. Undoubtedly some of the rods must be tighter than others, and the water pressure being uniform will subject these tight ones to the greatest pressure.

The safety of the pipe, therefore, under these conditions is undoubtedly due to the fact that the wood will accommodate itself by abrasion so that each rod will take its portion of the stress. If it were not for this effect the continuous wood-stave pipe would not be so reliable as the factory-made pipe, where the bands are wound on the pipe by machinery under uniform tension. The factory-made pipe has an additional advantage that the iron bands are readily protected by dipping and revolving the surface of the pipe in a hot asphaltic material, and afterwards rolling in sawdust. This forms an excellent protection, which cannot be done satisfactorily after the pipe is put in the trench. Another advantage of the flat bands is that they do not indent the pipe as do round rods.

But even if the pipe be first class in every respect, unfavorable conditions of installation and operation will soon cause trouble and undeservedly injure its reputation.

Where the soil is dry and porous and the pipe not continually subjected to a fairly strong pressure, the wood will not last many years, and

where a wood pipe is used as a pumping main and subjected to high pressure for a part of the time and to very low pressure for long periods, there is sure to be trouble due to leakage of the joints and the staves. There are some soils of a silty nature in which wood and iron will last indefinitely, even if the pipe is not subjected to material pressures. The ideal condition for a wood-pipe conduit is where the entire pipe is always subjected to fairly constant pressure. Such a condition is obtained by pumping to an elevated reservoir kept constantly supplied with water, and, when the pump stops, the pipe is under the pressure of the reservoir. If the friction when pumping is such that the pressure at the pumping station is, say, 75 lb. per square inch, and when the pumps stop, only 30 lb. per square inch, the conditions can be considered good. In a gravity main, if the pressures at the inlet and outlet ends are always not less than 20 lb., and not greater than 150 lb., the conditions may be considered good, provided the pipe is not operated under a low pressure for a long period and later under a much higher pressure.

As an example of very bad practice, a 24-in. wood pipe was laid along a salt marsh for many miles from the pumping station to a standpipe; the pumps usually worked from eight to fifteen hours per day. The pipe was not entirely submerged in the soil, and the tides covered and uncovered the pipe every day. Soon a considerable amount of leakage resulted, to avoid which the owners of the water works installed at the standpipe a check valve, which closed as soon as the pumps stopped. This allowed the pipes to become practically empty and accumulate air. Naturally, conditions rapidly became worse, so that in a few years the pipe was in bad condition and discredited. For a condition like that it would have been much better to have laid the pipe exposed on supports above the action of the tides, and accessible for inspection and repairs; then it should have been subjected always to the pressure of the standpipe even when the pumps were stopped, and no check valve should have been installed.

Another case consisted of a 24-in. wood pipe ten miles long. This was machine spirally banded, and the joints were mortise and tenon. The wood was of Norway pine, 2 in. thick. The pumps worked at about two and a half million gallons per day, which subjected the pipe to a pressure at the pumping station of 18 lb. per square inch. The outlet was in the bottom of a reservoir about 6 ft. deep, and when the pumps were stopped, the pipe was subjected to 12 lb. per square inch hydrostatic pressure. The country was very flat; there were no elevations more than 28 ft. above tide. The pipe was laid with an average cover of about $2\frac{1}{2}$ ft., and crossed under the deep ditches of the various farms, these ditches being from 1 000 to 3 000 ft. apart and some 3 to 6 ft. deep. The result was that the line consisted of a series of summits and depressions at the ditches. While there was a large amount of leakage at first, this gradually took up, so that after a year the total leakage was not more than 50 000 gal. per day. After five years of operation under these conditions it was decided to pump at the rate of 8 000 000 gals. per day through the line, which would cause a pressure at

the pumping station of about 60 lb., but the iron banding was originally good for 80-lb. pressure, so there was no difficulty on this score.

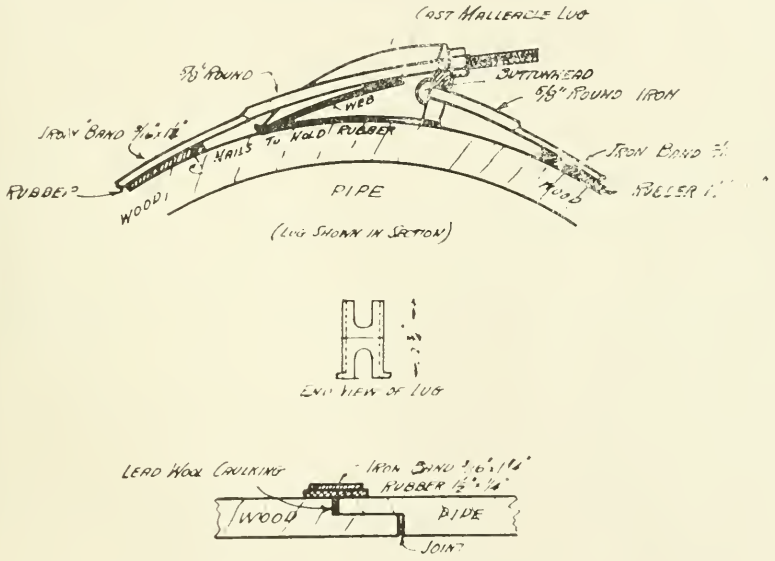
Duplicate electrical pumps were installed, and when the first was ready to operate, water was pumped through the line at the rate of about 5 000 000 gal. per day; pumping pressure 30 lb. per square inch. The leakage was inordinately high. In order to locate this leakage, line valves were successively shut and pumping was continued with a by-pass to the suction well, open sufficiently so as not to cause a pumping pressure of more than 30 lb. It was found in the first 11 000 ft. under this pressure there was a leakage of 4 600 000 gal. per twenty-four hours, or nearly the full capacity of the pump; and that a slight reduction in pressure reduced the leakage materially. An examination of the line showed that this leakage took place in nearly every joint and along the stave joints for the first five miles, the amount increasing near the pumps.

After many days' tests and examinations, it was decided to repair the joints of the first two miles, and band the first mile with independent $\frac{5}{8}$-in. round rods and double lugs, spacing the rods $4\frac{1}{2}$ in. apart.

After this work was done, a test of the first section was made, subjecting the pipe to about 65 lb. pressure, and the leakage was reduced from 700 000 gal. under 21 lb. pressure to 100 000 gal. per twenty-four hours under 65 lb. pressure.

Before a satisfactory repair joint was designed, many experiments were made. The first, designed by the manufacturers of the wood pipe, consisted of a steel band clamp, 4 in. wide, about $\frac{1}{4}$ in. thick, spaced around the joint and clamped at the top by means of a bolt, using tarred jute between the clamp and the pipe. These were only temporarily successful, and, besides, very costly. The next plan was as follows: 6-in. steel bands placed over the joint, leaving $\frac{1}{2}$ in. space, were made in two sections and bolted together, and, the joint having been calked previously with lead wool or jute, the space was then filled with leadite. This also did not prove successful, because the leadite soon deterioated the material, particularly the bolts, so that within a week or more they broke under pressure. Pure cement was then used, which proved successful and permanent, but the cost was high on account of the large bell holes that were required to make a good job at the bottom of the pipe; and the trench was wet, which increased the difficulty. Finally a joint was devised which proved practical, economical, and successful. The joint was scraped off all around the pipe, and at the top for a length of 12 in. it was calked with lead wool. A strip of rubber 75 in. long, $1\frac{1}{2}$ in. wide and $\frac{1}{4}$ in. thick was stretched around the pipe and centered directly over the joint and tacked on the pipe at each end, leaving a space between the ends of about 6 in. Upon this was placed a wrought-iron hoop $\frac{3}{16}$ in. thick, $1\frac{1}{4}$ in. wide, and made taut by a bolt and lug. There were two ways of making the band. One was to forge one end into a $\frac{5}{8}$-in. round for a space of 4 in., leaving a button head on the end; the other end was forged into a $\frac{5}{8}$-in. round for 7 inches and a $\frac{5}{8}$-in. standard thread cut

for the distance. A single standard malleable iron lug was used, as shown in this sketch. The other method of making the bands proved the most practicable. A $\frac{5}{8}$-in. round rod was flattened out to the required thickness and width by means of a steam hammer, leaving the ends the required shape. It was found best to bend the rods to circular form at the place of fabrication. These rods could readily be put in place by average men after two or three days' practice. The work was done without interrupting the service of the pipe line, but before back-filling the trench a valve was



SKETCH SHOWING METHOD OF BANDING 24" WOOD PIPE JOINT

closed and the pressure brought up to the maximum, and any joint that leaked was tightened at the lug and the bands hammered on the sides where necessary.

An attempt was made to substitute for the rubber band $\frac{1}{16}$-in. sheet lead, which was far less costly; but this was not nearly as satisfactory on account of its lack of flexibility, so that it was very difficult to stop the leaks, especially where the surface of the pipe had any irregularities. Besides, many years' previous experience under like conditions had proved that the rubber effected permanent repair.

After the first mile was made tight by banding the entire pipe and renewing each joint, it was found that stave leaks could be stopped by driving hardwood wedges between the iron bands and the staves at the horizontal center of the pipe, so it was not necessary to put independent rods and lugs on more than about 8 000 ft. of pipe, and it is quite likely that if the

subsequent conditions were known in the beginning, even the first mile would not have had to be treated in this manner.

After the repairs were made in what was considered a sufficiently satisfactory manner a test was made of the entire 40 000 ft. of pipe pumping through the line at the contract rate, equivalent to over 8 000 000 gal. per twenty-four hours. The leakage was found to be about 200 000 gal. per twenty-four hours, which was determined by making a Pitot tube measurement at both ends of the line, while the pumping continued at the same rate. The Pitot tube was checked by means of a Venturi type of meter at the pump end, and the discharge at the upper end was checked also by means of a rectangular weir, but the close measurement of leakage was determined in the following manner. While the pumping was going on at the contract rate, pressures were taken every mile and recorded. Then at the pumping plant a 2-in. by-pass with a 2-in. Empire meter was laid around a main valve. The line was then divided arbitrarily into six sections, the division points being the existing gate valves. The sixth valve, or farthest from the pump, was closed and the pump was kept working at the regular rate, discharging sufficient water into the suction well through the by-pass until the pressure at the pumping station equaled that which was previously found on the sixth section, and the discharge through the Empire meter recorded.

Then the fifth valve was closed and the same pressure maintained on the line. The Empire meter reading was then recorded, and the difference between these two gave the leakage on the sixth section. The by-pass was then closed sufficiently to subject the line to the pressure corresponding to that previously found on the fifth section, and the meter reading recorded.

The fourth valve was then closed and the remaining part of the line subjected to the pressure previously found for the fifth section, and the meter reading again recorded. The difference between these last readings represented the leakage on the fifth section.

In this way the entire line was tested, and the sum of the separate leakages represented the total leakage on the line under normal conditions.

At the pumping station the maximum pressure when pumping through the entire line was about 58 lb. per square inch, and the pressure at the far end for the test was not more than 13 lb., so under these conditions the Empire meter did not have to discharge at any time at a higher rate than 70 gal. per minute

There was one very important feature, without which it would probably have been impossible to have repaired this line at all, and that consisted of the use of white-pine sawdust, which was applied in the following manner: A connection was made with the suction of the pump and the bottom of an open barrel, which was kept full of water by a spigot at the top. Sawdust was stirred into this barrel, and the valve to the suction opened a sufficient amount so as to apply about 100 lb. of sawdust an hour. The pump was run at full rate, and a calculation was made to determine when the sawdust would reach a certain line valve. This was then shut by pre-arrangement

and the by-pass opened back to the suction, so that the pressure on that portion of the line would be no greater than it would be under regular operation. The sawdust would then stop the leaks, and discharge through the line was determined by the station meter. In this way the entire line was treated, and the leakage immediately reduced by at least 50 per cent., and the effect was permanent, not so much due to the sawdust as to the following condition:

This pipe had been subjected to only 18-lb. pressure for the first four years, and the earth fill over the top of the pipe had exerted sufficient pressure to gradually flatten the pipe, so that by test it was found that the horizontal internal diameter was $25\frac{1}{2}$ in. and the vertical diameter $22\frac{1}{4}$ in. A similar condition prevailed practically through the length of pipe. When the high pressure was put on, the pipe assumed a circular form, which could be seen by a crack along the surface of the ground over the pipe. Naturally this resulted in the leakage at the horizontal diameter of the pipe, and at the joints. After operating the pipe a considerable time under the higher pressure, a large amount of the leakage took up naturally, and it is quite probable that if this principle had been recognized in the beginning a great deal of the repairs could have been avoided by simply using sawdust at once and then maintaining the pumpage at the maximum for several weeks. Without the sawdust the high pressure could never have been secured, as the amount of leakage was so great as to cause trouble to the land all along the right of way. It is probable, however, that a considerable amount of the joint work could not have been avoided in any case. This experience proves how important it is to maintain a wooden pipe line at nearly the maximum pressure to which it is to be subjected, because wood being an organic substance will gradually accommodate its shape to the forces acting upon it.

An interesting feature in connection with this concerns the coefficient of discharge. Before the repairs were made, the coefficient was 95 in Chezy's formula, and afterwards 111. That is about the difference that would be caused due to the change in the hydraulic mean radius, resulting from a round pipe and one flattened as indicated.

Many exploiters of concrete, wood and even steel pipe try to create the impression that the coefficient of discharge is superior to that of cast iron, but it is believed for a given shape the coefficient of discharge depends on the degree of roughness and not on the character of material of the interior surface.

Discussion.

Mr. Ledoux. I should like to ask if there are any members here who know of any distribution systems that have been laid of wooden pipe, and whether they have been satisfactory for any length of time.

Mr. Allen Hazen.* I remember the water supply of Du Bois, Pa., laid in that way, that had the curious effect of reducing the sulphates. There was some mine water in it, and as the water ran from the pipes the hydrogen sulphide in it was very disagreeable.

Mr. Burt B. Hodgman.† I have had some experience with wood pipe and also with cleaning pipes. Mr. Ledoux has said that certain pipes deteriorate after cleaning in one year. That is quite true. But we do not believe that to be so as a general rule, any more than you should discard cast-iron pipe because it breaks, or steel pipe because it pits. But there are places where cleaning is stood off for ten or fifteen years.

In regard to wood pipe, I had considerable experience in Spokane, Wash., where I tested out with a pitometer something like 30 miles of distribution pipe from 4 in. to 8 in. in diameter. It was not satisfactory under those conditions because of the great changes in pressure, varying from 18 lb. during the high irrigation hours to 90 lb. under normal conditions. Leaks developed almost everywhere, and a little too fast to stop.

Mr. Arthur W. Dudley.‡ Wood pipe is in use at Antrim, Troy, Campton, Freedom, Pembroke, Penacook, Hudson, and Bristol, N. H. The pipe at Antrim and at Penacook are the oldest installations, having been in service twenty-five and twenty-four years, respectively, and have given perfect satisfaction; that at Penacook is now incorporated with the Concord, N. H., water system. The Campton pipe was laid under the direction of the writer in 1908, and that at Freedom in 1912; the maximum pressure at the former is 104, and at the latter 120 lb. Both are in perfectly satisfactory condition, and have never developed leaks or other trouble since their installation. Pembroke and Troy were constructed in 1914, under my supervision. At both of these places the supply lines are wooden pipes, and the distribution systems cast-iron pipes, with the exception that the line on Pembroke Street, some $4\frac{1}{2}$ miles in length, is wood pipe. The supply line, from Lake Pleasant in Deerfield, N. H., to Suncook village, in the town of Pembroke, slightly over 14 miles, is laid with 16-in., 14-in., and 12-in. wood-stave pipe. About $3\frac{1}{2}$ miles of the lower end of this 12-in. pipe, before entering Suncook village, is under a head of from 286 to 312 ft. This pipe was laid with the greatest care by a representative of the pipe factory under the close supervision of the writer, and has never yet shown the least indication of leakage or any other trouble. At Troy, N. H., they have $2\frac{1}{2}$ miles of 12-in. supply pipe. Here we had a rather singular experience. My inspector reported several leaks, and asked me to advise

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† Civil Engineer, New York.
‡ Civil and Hydraulic Engineer, Manchester, N. H. (*by letter*).

him what to do; I could not go there at the time, and when I went, several days afterwards, we were utterly unable to find them, and they have never since been discovered. They were undoubtedly over dry joints that soon swelled up and have since remained tight.

At Hudson and Bristol they have supply lines, laid under the supervision of a Nashua engineer, that, as far as I know, are satisfactory. There are also extensions at Lisbon, N. H., and at Northumberland, N. H., where short lines of wood pipe have been installed. The only failure that I have any knowledge of was at Peterborough, N. H., where 600 ft. put in last winter, by a careless and inexperienced party, without any supervision, had to be relaid. This pipe was dropped in any which way, the joints not more than half driven, and big stones thrown into the trench on to the pipe; and as it was under a pressure of 126 lb. it was a foregone failure.

Mr. Hazen. There is a physical limit to the pressure which can be carried in wood pipe. I will tell you my personal basis for that. Some years ago we were designing some pipe where there were a good many trolley tracks, and we wanted to put in some insulation joints. They were in fashion then. We thought that wood pipe was the easiest way to get a good insulation, and these were made of as good design and of as good material as we could find; but when we came to the test they could not be made tight. We had rather high pressures, running up to 150 lb. We could not get hoops that would hold that pressure without crushing the wood fiber. The leakage was not very great, but the pipes could never be made tight.

I was telling that to a manufacturer of wood pipe in his factory, one day. We were using miles of such pipe during the war. And he said, " Oh, we can band pipe to stand a pressure " — I have forgotten what he said, — 200 lb., we will say. I told him my experience. He said, " Let me show you." They had a testing machine, and a piece of pipe built for high pressure, and put it in. The pressure was put on. " See, it doesn't leak," he said. It was just a matter of definition. The pipe was sweating all over, but there were no jets of water from it. How much it would leak in a mile I do not know. But the manufacturer of that pipe said, " It is tight; you can see it stands; it does not leak."

Mr. J. W. Diven.* The last piece of wood pipe put in in Elmira, was put in in 1875. That pipe was banded, and it did stand a pressure of 110 lb. It was a force main from the pump to the reservoir. The pressure at the pump end was 110 lb. The pipe was tarred and rolled in sawdust and tar, and rolled in sawdust again to protect the bands. There was no appearance of sweating on the outside of that pipe at 110 lb. pressure. But that was a bored pipe, and the shell was 4 in. thick.

Mr. Ledoux. In 1908 we laid 7 000 ft. of wood pipe on the Monongahela Division of the Pennsylvania Railroad. This was part of the large system of the railroad supply comprising some 600 miles of pipe from 12 to

*Secretary, American Water Works Association.

36 in. in diameter. For this particular section wood pipe was selected on account of the necessity of laying it in a cinder fill. The makers of the wood pipe assured me that they had a coating which was absolutely proof against corrosion due to the acid of cinder banks, and I took a chance. The working pressure was specified to be 150 lb. per square inch, and that is the pressure that was actually on the line. When the pipe was first laid there was very much leakage, which continued about two weeks and then gradually decreased until it practically disappeared. The leakage was measured by means of a small meter on a by-pass around a valve at the inlet connection of the cast-iron pipe. This pipe continued to give good satisfaction for nearly two years, after which it began to give serious trouble. It was found that the iron bands had been so eaten through by the acid in the cinders that it was decided to replace the entire line. If the soil had been neutral I have no doubt the pipe would have continued to give good results.

I do not believe there is any coating made that will withstand those conditions, and I am sure that cast iron would not have stood for more than two or three months, an opinion which was confirmed by other similar experience, so that we found it necessary under conditions of that kind to encase the cast-iron pipe in concrete.

This 7 000 ft. of wood pipe, however, was replaced by cement-lined pipe manufactured by the American Pipe and Construction Company of Philadelphia, and in answer to a recent inquiry I learn that there has been no trouble with the pipe since it was laid. Unfortunately, the above company stopped making that kind of pipe.

Mr. W. C. Hawley.* Since such a large amount of sectional wooden pipe was used by the Government during the war, I am wondering if some water-works men who were in the service can give us an idea of the leakage to be expected from this class of pipe.

I had an experience some years ago which did not convince me that the manufacturers had very much confidence in it. I designed a 12-in. cast-iron pipe line as a supply line from a reservoir, and the manufacturer went to my client and wanted to sell him the sectional wooden pipe at quite a saving in cost. The price was a very important thing to that company; but, on the other hand, leakage was even more important, because the amount of water which could be collected from that source was limited and every gallon was needed. The matter was referred to me, and I finally made a proposition to the manufacturer that if he would give a guaranty that his pipe line would, for a period of five years, be as tight as we would expect a cast-iron line to be, we would put it in. Of course when we began to talk he was perfectly confident that the pipe line would not leak and willing to "guarantee" it, but when it came to putting a bond back of that guaranty he would not do it.

I put a short piece of pipe, a 12-in. section, in a force main, some years ago, to increase resistance to the flow of electricity and thereby to prevent

*Chief Engineer, Pennsylvania Water Works Co.

damage from electrolysis. The pipe was put into a trench which was in the rock, and the bands or wire on that wooden pipe lasted not over three or four years.

Mr. Diven. Steel or iron?

Mr. Hawley. I do not know. We replaced it, and the new pipe has been in service now some twelve to fourteen years, and we have had no further trouble with it.

As to the maximum pressure on a continuous wooden-stave pipe, my recollection is that 90 to 100 lb. is considered the limiting economical pressure, for above that the amount of steel required in the bands becomes equal to the amount of steel in a sheet-steel pipe, and there is no economy.

Mr. Diven. I think about 1860 the white pine, of which the wood pipe was made, sold for about $87. The same wood to-day is worth something like $400, and hard to find at that.

Mr. Frederic I. Winslow* (*by letter*). The experience of the city of Boston in the use of a 30-in. cement-lined wrought-iron pipe laid by the city of Charlestown in 1870, before its annexation to Boston, shows that a large pipe of this material has a life of at least fifty years, if—emphasis on this *if*—it is undisturbed, and is laid in solid ground. The only trouble comes when it is necessary to make connections with it, to insert a gate; or when it has been mistaken by an over-enthusiastic laborer for a sewer.

On the other hand, all of the smaller sizes of cement-lined pipe similarly made have long since been relegated to the scrap-heap, as the iron skin corroded. A suggestion originally made by the late Freeman C. Coffin, I believe, contains a valuable contribution to this subject, namely, the use of a cast-iron pipe lined with cement. This has never been carried into effect, so far as I am aware.

It would be very difficult, I fancy, to induce New England water-works men to introduce wooden pipes to carry heavy pressures, or even as low as Mr. Ledoux states they are safe at; although at many of the war plants wooden pipe was used for sewer work.

If the remarks regarding the short life of a cleaned pipe are true, it would necessitate the organization of a pipe-cleaning department in larger cities.

Mr. J. J. Wilson. The author points out that, for water-works pipes 24 in. in diameter or larger, a consideration of various materials is advisable. Among such materials, lap-welted steel pipe, which has been used for water mains for the last thirty years, and which has lately become available in much larger sizes, merits consideration. Steel pipe has gained much ground the last few years because of evident advantages, among which are its general reliability and economy. The reliability of steel pipe has been proven through thirty or more years of service, during which time remarkably few failures have been recorded. This reliability under severe conditions is due to the strength of steel and its ability to withstand strains

* Consulting Engineer, Framingham, Mass.

without breaking. An instance of this nature occurred during the summer of 1921, when during a severe flood at Colorado Springs, Colo., washouts occurred which left a line of steel pipe suspended for a span of 150 ft., without interruption to service. The Baltimore high-pressure fire system, of steel pipe, has been installed for ten years without a serious leak or break. Many other instances could be cited. The economy of steel pipe lies in the fact that it is relatively cheap in first cost and to install, considering the service it gives. Many instances are on record of installations lasting for periods of twenty-five to thirty years without serious corrosion troubles. A 24-in. diameter disk, cut from a 48-in. steel main in Pittsburgh, after twenty-five years showed no measurable corrosion. Some failures of early installations of steel pipe may be attributed to a lack of knowledge of proper methods of protection against corrosion. Steel-pipe coatings have now been developed to such an extent that corrosion of the interior is in most cases negligible, with the result that the carrying capacity of steel pipe is not lessened with age to nearly the same extent as cast iron. Outside corrosion can be effectively prevented by proper coating to withstand conditions. In most pipe lines, soil conditions vary at different places in the line, corrosive influences at some places being more severe than at others. Extra protection should be provided for the more dangerous places, and with the present knowledge of causes of corrosion and means of prevention, such protection as will best meet conditions can be readily applied.

Perhaps the best proof of the service of steel pipe lies in the fact that almost all cities that have once used steel for their large mains, use the same material for extensions. The city of Rochester, which has been cited as having experienced considerable corrosion in the first steel conduit installed there, decided in favor of steel for its third conduit on the basis of general reliability and ultimate economy.

Recently a large plant has been installed by the National Tube Company, for manufacture of hammer-welded steel pipe from 24 in. to 96 in. diameter, in lengths up to 40 ft. Lap-welded pipe was previously made by the old process in sizes from 2 in. to 30 in. diameter.

THE DISAPPEARANCE OF THE COATING FROM CAST-IRON PIPE WHILE STORED IN THE YARD.

BY SAMUEL E. KILLAM.*

[*Read September 14, 1921.*]

Coating for cast-iron pipe to be used as a water supply is a subject about which much has been written during the last century. Many experiments have been made, all in the hope of finding a coating for the pipes which would give a perfect protection against the formation of tubercles after the mains had been put into service. The results of these experiments with coating have been almost negative, and the delivery capacity of the mains after they have been put in service gradually decreases until we find after fifteen to twenty years the delivery has been reduced 25 per cent.

On the Metropolitan Works of greater Boston it is necessary to maintain storage yards for large amounts of pipes and special castings for use on emergency repairs, as part of the system was acquired from the city of Boston and the remainder was laid under specifications adopted by the Metropolitan Water Works and the New England Water Works Association. Similar conditions exist on all extensive works.

During the twenty-five years in which the pipe has been received from the foundries there has been very little change in specifications as to the requirements of the coating on pipes cast.

The requirements for coating under present specifications are as follows:

"Every pipe and special casting shall be coated inside and out with coal-tar pitch varnish. The varnish shall be made from coal tar. To this material sufficient oil shall be added to make a smooth coating, tough and tenacious when cold, and not brittle, nor with any tendency to scale off.

"Each casting shall be heated to a temperature of 300° F. immediately before it is dipped, and shall possess not less than this temperature at the time it is put in the bath. The ovens in which the pipes are heated shall be so arranged that all portions of the pipe shall be heated to an even temperature. Each casting shall remain in the bath at least five minutes.

"The varnish shall be heated to a temperature of 300° F. (or less, if the engineer shall so order), and shall be maintained at this temperature during the time the casting is immersed.

"Fresh pitch and oil shall be added when necessary to keep the mixture at the proper consistency, and the vat shall be emptied of its contents and refilled with fresh pitch when deemed necessary by the engineer. After being coated, the pipes shall be carefully drained of the surplus varnish. Any pipe or special casting that is to be re-coated shall first be thoroughly scraped and cleaned."

* Superintendent, Distribution Section Water Division, Metropolitan District Commission, Boston.

There is in storage, in the Metropolitan yards, pipes and special castings valued in stock at about $70 000. Many of these castings have been stored for about twenty-five years. A considerable number of these still have only the original coating, although places have been touched up with a brush where the coating was injured in transit or in handling in the yards.

Good coatings on pipes in storage will remain smooth and tough, softening from the heat during the summer months, and show no tendency to crack or scale off in cold weather.

In recent years the coating has been affected by the atmospheric conditions in from five to ten years after the pipes are received from the foundry. The pipes are stored in the yards on skids, but the coating on the interior surfaces is in many cases as much affected as the exterior surfaces.

It is impossible to protect in open storage the coating on special castings such as caps, plugs, etc., as the moisture collects in the depressions and within a few months the coating will entirely disappear.

On many pipes received from the foundries the coating will begin to disintegrate in rings 4 to 6 in. wide about $2\frac{1}{2}$ ft. from the bell and spigot. This rusting and disintegrating of the coating is believed to be caused by the fact that the pipes are rolled on skids at the foundry before the coating has had sufficient time to harden.

During the war some pipes were received at the yards from the foundries, which had been passed by inspectors, where the coating had entirely disappeared on an area of several square feet, sometimes on the inside and sometimes on the outside surfaces. The coating had vanished in transit, leaving the pipes uncoated and rusty. The inspector and foundry officials were unable to explain why the coating had disappeared. A complaint was forwarded to the foundry and the coating on the remaining shipments of pipe was satisfactory.

In 1866 engineers of the French navy made many experiments with pipe coating. At last they perfected a coating nearly like our coal-tar product of many years ago. A pipe was coated and submerged in salt water for one year, and at the end of that time it was found that the coating was in good condition, but, as far as the writer has been able to learn, nothing further ever resulted from these experiments. Compare this test, if you will, with that actual test of the coatings on the cargo of pipe bound for New Bedford some years ago, when the barge sank off shore and in about two weeks the coating which remained was so poor that it was necessary to clean and cold-dip all of the pipe before they could be salvaged.

Coal tar of to-day is very different from the coal tar of seventy-five years ago and the products from various gas works differ widely as to ingredients. It has been said that during the latter part of the war any black semi-fluid that came from the gas works passed as coal tar.

Dr. Smith's process, of which you all have heard, calls for dipping cold pipe in hot tar for half an hour, or until the pipe gets thoroughly warm.

Can you imagine our foundries of to-day, with their enormous output, allowing each pipe to remain in the coating for this length of time?

A foundry owner recently said to the writer that the makers of cast-iron pipe were perfectly willing to give the consumers what they wanted if the consumers were willing to pay the price.

The writer believes very strongly that as engineers and water-works men we should be in a position to specify what materials are required and the method to be followed in coating pipes and special castings.

Do we know what we want? If not, are we willing to pay the price to find out what combination of materials makes the most durable coating and are we willing to pay the additional cost for that coating?

Discussion.

Mr. Allen Hazen.* The Spring Valley Water Company of San Francisco has met a similar condition by establishing and operating a dipping tank in its yard. In this tank all old pipe, and all defective pipe, and new castings made locally, and, in short, any pipe there is any reason to question, is re-dipped immediately before it is laid. It is not a very expensive matter for the company to keep up this tank and operate it occasionally and it is a satisfactory means of overcoming that difficulty, and tends to maintain the high standard of the company's work.

I want to add also that I think the time is coming, or perhaps has come, when better specifications for coating cast-iron pipe ought to be adopted. In riveted pipe made of steel and wrought iron much better coatings have been used. They cost more money, but are worth it. I am inclined to think that as good coating as is actually put on steel pipe would pay dividends on cast-iron pipe.

Mr. J. M. Diven.† Did they heat the pipe before dipping it, in San Francisco?

Mr. Hazen. Yes; I won't say the same as at the foundry, but it is heated a great deal.

Mr. Franf A. Barbour.‡ Of course this question of coating is a very live issue with your Committee on Standard Specifications for Cast-Iron Pipe. We had a meeting this morning, and voted, among other things, to send a communication to the manufacturers, asking them to state whether they would be willing to coöperate with us in the development of a better coating. That involves experimental work and a considerable expense, and it is necessary for us to know how far the manufacturers will go. There is no doubt that a great many of the manufacturers at the present time are experimenting with different pipe coatings, and that they fully realize that the present coating is not satisfactory.

* Consulting Engineer, New York, N. Y.

† Secretary, American Water Works Association.

‡ Consulting Engineer, Boston, Mass.

At the meeting of the American Water Works Association I had something to say for the committee of that association, and one or two men representing towns came to me and said that they believed their water boards would be glad to contribute something towards the development of a better coating. Whether that would be practicable, or whether this Association, or any other association, should accept money in that way for such an investigation, I do not know; but there are certainly a great many men who feel that it is one of the big issues.

Mr. Diven. There is no good reason why the Association should not accept, or even ask for, contributions for such a purpose, as with the very small dues it could not be expected to do research work. The result of such work would be of great benefit to many water works, and if attempted by them individually would certainly cost each many times the small contribution needed from each to create a fund to permit the association to do the work thoroughly.

The process of gas making has been radically changed, and it seems probable that the production of gas tar has also changed or possibly been greatly reduced by the change from coal gas to so-called water gas.

The speaker has never noticed that the coating of valves deteriorated more than that on pipes, though it is his understanding that they are not dipped, but painted with some cold preparation or composition, as the heating of a finished valve to the required degree for dipping would be apt to warp it.

Mr. Killam spoke of the inventories of pipe and specials on hand, and the charge for them when used. Were these made on the cost price or the replacement price?

Mr. Killam. Original cost; what we call the "stock value." Every pipe that comes in the yard is listed, the original cost, including cost of transportation and handling. This stock value is entered on cards, and when the pipe or special is delivered to the works it is charged off to that piece of work.

Mr. William R. Conard.* Mr. Hazen spoke of the Spring Valley Water Company having facilities for re-coating their pipe. The city of Springfield also has facilities for doing that work in their pipe yard. They have installed a coating tank and an oven for heating the pipe and for heating the coating. Some years ago, when they were able to make a purchase of a quantity of pipe at a nominal figure, on which the coating was in rather a poor condition, they bought the pipe with the understanding that they would re-coat it at their own expense. That was one of the objects of making the purchase, which was at a low figure.

Speaking of the cargo of New Bedford pipe which deteriorated so rapidly, the cost of the re-coating was at the expense of the insurance company. The type of coating which was used was, as Mr. Killam said, a cold dip, or paint. It was a structural steel paint which was purchased, and

* Inspection Engineer, Burlington, N. J.

which at the time was rather costly, although the insurance company, in order to make an adjustment, and have the cargo accepted, was very glad to furnish the materials. That pipe was re-coated by building a wooden tank and filling it with the cold dip, and simply lowering the pipe in and coating the same as though they had been previously heated. There were no facilities at that time to heat the pipe, and because of the character of the coating which was put on it was not necessary to re-heat it. Some two or three years after that pipe had been re-coated I looked at some of it in the storage yard at New Bedford, and the coating had, as we term it, weathered very well, — it was still in good condition.

Practically all gate valves are painted cold, the material being applied with a brush. The interior of the body and the bonnet, after the machine work is done on them, are painted inside, then the valves are assembled, tested, and afterwards the exterior and the inside are painted for the second time.

Most of the valve manufacturers use what is termed an " asphaltum " paint.

Mr. Killam. I haven't any doubt but Mr. Conard can tell us if the material for pipe coating that is used at the foundries is purchased from gas works.

Mr. Conard. Nowadays the coal tar is controlled practically by one concern, — the Barrett Manufacturing Company. Practically all the coal tar used by the pipe foundries is purchased from the Barrett Manufacturing Company. Even after the gas company gets through with it, I understand the Barrett Manufacturing Company tries to get some by-products out of it.

Mr. Hazen. I have been recently assured by a competent representative of the Barrett Company that they could still sell tar of the old-fashioned quality. I think it is possible to get this tar of the same chemical analysis; but chemical analyses may not tell the whole story, and I do not feel sure that there may not be differences with analyses that seem to be the same. The methods of chemical analyses of coal tar were developed by Dr. Dudley, of the Pennsylvania Railroad. Dr. Dudley gave this matter a great deal of attention and determined the kind of coal tar which gave the best results as a protective material in railroad work.

Mr. Conard. I am very glad to hear Mr. Hazen say something about there having been at some time a thorough analysis of coal tar. I have tried time and time again to get hold of some such information. I don't know whether that information might be available or not for the consideration of the Pipe Specifications Committee — I think they would be very glad to have it if it could be made available. They should also find out whether the various components were ever determined, and what their effect might be on iron.

Mr. Barbour. I might say that the tentative specification which has been used by the committee for some four or five years contains a specification for coal tar which was largely based, I think, on what Mr.

Hazen used on the Springfield line, and I think that specification is probably based on what he refers to as Dr. Dudley's work.

MR. HAZEN. That is correct.

MR. BARBOUR. So that it is already in our tentative specification. If we could get that, I think we could get real tar.

MR. HAZEN. I knew Dr. Dudley very well. He was one of the ablest scientific thinkers of the country. I do not know whether he ever published anything about his coal-tar work, but at the time of the Springfield work I asked Dr. Dudley, as my personal friend, to give me the benefit of his experience in writing the specifications; and the specifications thus drawn have been used, with some slight modifications, ever since.

MR. DIVEN. Does any one know whether in the manufacture of water gas, which is coming to be very general, any gas tar is produced?

MR. HAZEN. I think that is an entirely different kind of tar. It is some time since I have been through a water-gas plant. I think that they do produce tar, but that the tar is of a different quality, and probably not suitable for coating.

WATER-WORKS ACCOUNTING.

[*September 15, 1921.*]

(Discussion and Adoption of Committee Report presented at 1920 Convention; published in the JOURNAL for March, 1921.)

PRESIDENT SHERMAN. The subject scheduled for this evening is that of water-works accounting, which was reported upon to this Association at its convention last year. The report, as your program advises you, was published in our last March issue of the JOURNAL. It was received at the Holyoke Convention and laid on the table pending its publication, as it was obviously a type of report which it was impossible to discuss without seeing the detailed forms recommended by it. No discussion was possible at that time. It is now in print, and it has been in the hands of the members for several months.

The report is now before you for consideration.

MR. SAMUEL H. MACKENZIE.* As one member of the Accounting Committee, I regret very much that Mr. Hathaway, who was on that committee and who, perhaps, is the best-qualified member to discuss it, is unable to be present to-night; nevertheless, as we have had ample time to consider the matter, it seems wise to bring it before the meeting for discussion; and in order that definite action may be taken I will offer the following resolution:

Whereas, at the present time in this country all privately owned and operated public water works are universally classed and recognized as public utilities, and as such are amenable to uniform accounting and other operating requirements prescribed by the public utility commissions of the several states; and

Whereas, municipally owned and operated public water works are likewise recognized and classed by the best and most competent authorities as public utilities (by some governmental authorities called "public service enterprises") instead of political subdivisions of municipal government; and in a growing number of states such municipally owned water utilities are also amenable to similar uniform accounting requirements as are the privately owned water utilities; and

Whereas, it is an undisputed fact that, in order that the operation of the municipally owned water utilities may compare favorably with the operation of the privately owned water utilities, the former will need to

* Engineer for Water Department, Southington, Conn.

adopt more of the efficient and businesslike practices of the latter, — one of which is the general use of a uniform accounting classification (such as is prescribed by the state public utility commissions), — so that proper and informing comparisons of results may be easily made between such water utilities; and

Whereas, a special committee of the New England Water Works Association has made an exhaustive study and report upon the present need of uniform accounting for municipal water works, and has recently submitted in outline a simple but comprehensive accounting classification in accordance with the latest essential requirements as prescribed by the best and generally accepted authorities:

Now, therefore, be it resolved, by the members of the New England Water Works Association, in annual convention assembled at Bridgeport, Conn., September 15, 1921, — recognizing and appreciating the facts set forth in the foregoing preamble, and desiring to further strengthen the Association in its enviable position as a leader of practical progress in water-works operation, — that this Association hereby adopts, as a standard, the Classification of Uniform Accounting for Municipal Water Works as submitted September 9, 1920, by its special committee and published in the Association JOURNAL for March, 1921; and earnestly recommends its use by any and all of its members to such extent and as soon as they may find it convenient and practicable to do so.

In presenting this resolution, I do it in conjunction and with the sanction of Mr. Hathaway, and it is done in order that this matter may be brought before you for discussion. If there is anything in the suggested form that does not meet with your approval, or could be improved upon, the committee hopes that you will make the fact known.

The classification as submitted to-day is in the hands of the Connecticut Public Utility Commission, and a conference is to be held in regard to it. But, as has been stated by our President, we think that we could bring it before the state authorities with more authority if it were adopted by the New England Water Works Association.

Accounting may be one of the disagreeable sides of the water-works business. It has to have a financial end, and if the plants or water works do not have a correct and proper system of accounting they cannot be run as they should. It is absolutely necessary, if the lines of defense which have been mapped out for us are to be carried out, that we should prepare for them; and if the plants are not run on a businesslike basis those lines of defense cannot be carried out. There is no commodity which is as necessary and important to the welfare of the human race as water, and it is our business to supply as good water as it is possible for us to secure. But that cannot be done without funds. Rates should be adjusted so as to furnish ample funds for the necessary requirements, and sufficient income collected year by year so that unnecessarily high rates will not have to be adopted

when the time comes to make extensive changes or renewals in our plants. As the population about our water supplies increase, many of us will have to adopt some of the lines of defense mentioned here to-day, and there is no better way to prepare for that time than by establishing a proper reserve for depreciation and charging adequate rates to care for the same and other necessary improvements.

President Sherman. The resolution submitted on behalf of the committee which prepared this report is before you for consideration. Is the motion for its adoption seconded? — (The motion is seconded.) It is moved and seconded that the resolution as presented be adopted. I might say, in continuance of what Mr. MacKenzie said in regard to the Connecticut Utilities Commission, that it is my understanding that the Massachusetts Public Utilities Commission is preparing a standard form of accounting for water companies, which is to be promulgated probably within the next two or three months, and I think that a form officially approved by this Association would doubtless receive careful consideration by the Utilities Commission in drafting their standard form. I have had personal occasion to give considerable study to the standard forms of accounting prescribed by the Maine Utilities Commission, and they agree very closely with the schedule as here laid out; in fact, the principles are identical. The only differences would be in names of accounts, and of course would be of no particular moment. Is there any discussion of the form of the report, or on the adoption of the resolution?

Mr. Bertram Brewer.* If anyone attempts to compile financial statistics about various water works, especially municipal works, from the annual reports, one is appalled by the lack of accurate information about the most essential facts, to say nothing of those covered by this comprehensive form; and while I believe in church spires and other things of that nature, it would be a pity to have the ideal so high as to discourage the local superintendent or accountant from inaugurating very much needed reforms which are really of a very simple nature. Probably it will not.

For instance, there is already the standard form of financial statistics of the Association which I believe the President has had some experience in trying to have adopted by the various water-works departments, and we all know with what success. If that simple form of financial statistics had been prepared and printed from year to year by all the water-works departments of Massachusetts it would be a simple matter now, for instance, to find out what each community has paid year after year for maintenance or for construction expense, and what the gross revenue amounted to,— things which every practical water-works man wants to know and every taxpayer ought to know. It is impossible to do this, with any degree of accuracy, in far too many cases to-day. My query is as to whether this new form will help the situation. Perhaps it will. I should like some light on it. I can see how you can pick these and many more facts from the vari-

*Assistant Engineer, Massachusetts State Department Public Health.

ous items in the schedule proposed, but if you cannot secure adoption of the simpler form already recommended, how can the adoption of an elaborate one be secured? It seems a pity that something more cannot be done to secure more uniform municipal accounting and a clear, balanced statement each year of the income and outgo, and perhaps I can emphasize this need by asking these questions.

If the President will pardon me for doing so, I should like to call attention to a balanced financial statement which is made annually by the Belmont Water Works. I have in my hand a copy of the last annual report, and I can say that it is a pleasure to get the reports of the Belmont Water Works. Any one can tell at a glance, from the annual financial statement, how much it is costing Belmont to supply water to its inhabitants and whether it is a paying or a losing business. Furthermore, the Belmont statement furnishes an admirable opportunity to compare this works with others.

Perhaps I am altogether wrong in thinking for a moment that adoption of this standard form is not going to help along the happy day when the townspeople who own the water works can tell just what are the results of their business venture in the procuring and distribution of this essential commodity.

President Sherman. I can say that from my point of view the adoption of this would help along just what Mr. Brewer is anxious to get. These forms recommended by our committee have to do with purely financial accounting; the book-keeping end, as you might call it, as distinguished from the superintendence or the operating end. It is impossible for the superintendent or the operator of the work to divide up his operating expenses or to find out how much per foot it costs him to lay pipe of a certain size until the book-keeper has put down the expenses and put them in the proper accounts. The main object of these forms is to get accounts which will lend themselves to subdivision into the several classes desired.

My own feeling in regard to this report is that it has been very carefully thought out by men who, it seems to me, are the very best water-works accountants we have among our members, and that we are probably in a position to make the best progress by adopting their recommendations. It is offered by the committee as the best thing they can present, and we hope the members of the Association will use it, but it leaves us perfectly free to amend it whenever it seems desirable to do so; for instance, if the utility commissions should make rulings which were at variance with recommendations here to such an extent as to require a change in the forms, it might be desirable, and in any such case our committee probably would come back and recommend that our forms be modified to correspond.

Mr. Brewer. That is just the information that I really wanted on the matter. Then, as I understand it, in most of the cities and towns, as things are organized, this sort of form would be taken care of by the auditor.

PRESIDENT SHERMAN. Precisely.

MR. BREWER. It is a form for him more than it is for the practical operator?

PRESIDENT SHERMAN. Oh, yes, the book-keeper or the auditor, or the town treasurer, or whoever it is that does the accounting work.

MR. BREWER. It would not discourage the operator from getting out the very best he could in a simple manner along the lines that I have indicated?

PRESIDENT SHERMAN. It is my belief that he would get the figures he wanted from the auditor, and with more satisfaction. Of course, as far as prescribing this thing is concerned, in most of our states at the present time it relates only to private companies. The Utility Commission in Massachusetts will have the right to prescribe only what shall be done by the private companies, if I am correctly informed, and its adoption by municipal plants would be entirely optional. In Maine the Commission has control over publicly owned utilities as well as privately owned, and the cities must report on these forms just as much as private companies. Is there any further discussion?

MR. MACKENZIE. The schedule of accounts submitted was drawn so as to be adaptable for use by large as well as small plants. Take, for instance, page 64. The accounts shown on that page might be the only ones that small plants would use. They would not have to subdivide their accounts as they are subdivided on the later pages of the report for large plants.

If you will go over the reports of various municipal departments, and even some private companies, you will find that they have simply kept a cash account, which is about the end of their accounting, and from that cash account you couldn't tell how much it is costing them to deliver water. They have taken no account of depreciation or the other various items that enter into the cost of their water supply. I hope that the report as a whole will not confuse any one and make them think that it is too complicated to be adaptable to smaller plants; for it is intended to be flexible enough for any water works to use.

I have here a schedule, such as we are using in a certain private plant; on the front side of the sheet appear the assets and liabilities, also the profit and loss for previous years and for the current year, and on the back side of the sheet appears the statement of receipts and expenses for the period which the report is made out for, and the net gain for that period, which should equal the net gain shown on the other side; such a system really gives a double set of double-entry book-keeping and usually checks any errors. And right from that report it is very easy, knowing the quantity of water you are furnishing, to determine what it is costing you for the various items. I would be glad to have the members look this schedule over and suggest any improvements which they may think could be made in it.

Mr. W. C. Hawley.* I had quite a little experience in connection with the preparation of the uniform system of accounting which has been adopted by the Public Service Commission of Pennsylvania. Such systems do seem very elaborate and confusing, but they can be simplified by the smaller companies and they can be elaborated as may be desirable for the larger companies. These are matters of detail to be worked out by the individual, although our commission has made four separate classifications for water companies based upon the total annual revenue. There is a very simple classification for companies with a total annual operating revenue of $5,000 or less; one which is more elaborate for companies whose total annual operating revenue is more than $5,000 but not more than $50,000. The next classification is based upon a revenue of more than $50,000 but not more than $250,000, and the next applies to those companies whose revenue exceeds $250,000. Some of the other state commissions have done the same thing.

But the important thing, and the thing which has been overlooked in the past by most water companies at any rate, has been to keep their accounts in such shape that when it came to a rate case, or a valuation of their plant, they could turn to their books and show what their plant was worth. Those engineers who have had occasion to go through the books of companies to try to dig out the information and find what the plants actually cost, realize what the difficulties are. Quantities and units price are not there. Time books and pay-rolls cannot be analyzed. Items that should have been charged to maintenance have been charged to construction, and vice versa, etc.

There is one thing about this classification to which I would call particular attention. I have not studied it carefully, — in fact I have only looked it over hastily, — but I have found no place for carrying as an asset the depreciation reserve fund, or replacement fund. Now, let us make a distinction between the fund and the "reserve." I do not know why the accountant uses that word "reserve." We generally, in ordinary language, put a different meaning on it from what the accountant does. In Pennsylvania they are carrying the reserve as a "red" asset. That is, they have taken it from the liability side and put it on the asset side as a "red" asset, immediately under plant value, so that by making the subtraction we get at once the depreciated value of the plant. Now, if you are going to maintain the investment — and that is the vital thing for a water company and those who invest in its securities who have to go before a commmission and justify its rates — you must carry a fund to offset the accrued depreciation. It will be said, "Why, you are taking that money and you are investing it in plant" — although you can't have it invested twice. You have invested it once in the original plant, and you are setting it aside year by year to offset the accumulating reduction in value of your plant and to have it ready to make replacements with as units of the plant become

*Chief Engineer, Pennsylvania Water Company.

no longer useful. If you put it into plant and carry it there, then you are simply reducing your investment that much and there is no available fund for replacements.

This has been recognized by the Wisconsin Commission, by the Commission of Indiana, and some of the other commissions. The Commission of Oklahoma has recently prepared, but not yet issued, an order by which all utilities would be compelled to carry a depreciation replacement fund, to take the money which is set aside year by year from depreciation and create an actual fund, that fund to be invested and to be available to make replacements as they may become necessary.

If we invest this money in plant, two things will happen. First, we will have the public service commissions rule, just as they have in cases all over this country, that your plant cost so much, or its value new is so much, and they subtract accrued depreciation and so arrive at the present value of the physical plant. If the company does not have in hand a fund representing that accrued depreciation, just that much of its investment is wiped out. It has no fund to offset it; that much is gone. So that if we are going to protect our investment it is of vital importance that the fund should be created and should be carried.

In the second place, there will occur what happened to one of our companies within a year or two. We had a very expensive pumping engine which had outlasted its usefulness and had to be replaced. Fortunately, we carry a replacement fund and had the money available with which to replace it. If we had been putting that money into our plant we would not have had money enough for two or three years, from what we set aside annually for depreciation, to replace that pumping engine.

I believe that this is a matter which merits serious consideration, from private water companies particularly. Municipal water departments may arrive at satisfactory results by creating sinking funds with which to reduce bonded indebtedness, and when replacements are necessary can issue new bonds. Water companies could do the same thing in the past, but not now. They are under commission regulation to-day, with rules prescribed for this and orders laid down for that, and rates of return limited to such an extent that the companies find it exceedingly difficult to secure new capital for extensions and betterments. The companies should, therefore, do what they can to remove the difficulties of securing new capital, and there is no more practical way than to protect as far as possible the capital already invested.

In this connection I call attention to the decision of the Wisconsin Railroad Commission in the case of Milwaukee Electric Railway and Light Company *et al. v.* City of Milwaukee (P. U. R. 1918, E. p. 1) and that of the Indiana Public Service Commission, *re* United Public Service Company of Rochester, Ind. (P. U. R. 1918, F. p. 316).

PRESIDENT SHERMAN. I might say, Mr. Hawley, that in the suggested system of accounts, although the account does not appear by name, it

would lend itself perfectly well to carrying that under Account 26, "Miscellaneous Current Assets," which, of course, in such a system as you describe, would carry a name opposite that particular account showing what it was, — that is, depreciation fund, or depreciation investment.

Mr. Hawley. That is what happened in Pennsylvania. We could not convince the accountant at the time that this was necessary. Later we were directed to carry the account as a sub-account under Account 113, "Insurance and Other Reserve Fund Assets." This is a separate, distinct fund, like the compensation insurance fund, fire insurance fund, and this particular fund we designate "Depreciation of Structures and Equipment Replacement Fund."

President Sherman. The Maine Utilities Commission has a special number for that account. As I remember the name for it, it is "Depreciation Reserve Invested," or something of that nature. But it would fit into this particular system of accounts under that general number, with the appropriate name under a subdivided head.

Mr. MacKenzie. I think Account No. 24 would take care of that, — "Cash (Special Funds)." That account can be subdivided into the reserve funds for engines, pumping station, pipe lines, or whatever account special circumstances might require.

President Sherman. Of course the "Depreciation Invested Fund" would be indicated as such in the particular account to show what it was.

Mr. George A. King.* I would like to ask Mr. MacKenzie if he can tell us how nearly these accounts agree with the accounts which were reported by the committee of the American Association about ten years ago, made under the direction of the Census Bureau?

Mr. S. H. MacKenzie. I can't tell you from memory the difference, now.

President Sherman. Is it safe to say the general principles are identical?

Mr. MacKenzie. Yes.

Mr. Edward D. Eldredge.† I should like to ask for information on one subject. If some of the surplus is not used for extensions, and charged off as a depreciation, possibly, from what source is the money to come for extensions or new work in the line of extensions? Would that call for a new issue of stock or money borrowed?

President Sherman. It would have to come from some source, obviously, — either from issue of new securities or, in case of municipal plants, by appropriations from taxes, or from donations, if such were available — I have heard of such things.

Mr. Hawley. The Indiana Commission permits the company to borrow temporarily from this fund for extensions. I think there is a limit as to the time that money may be had.

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* Superintendent, Water Works, Taunton, Mass.

† Superintendent, Onset, Mass., Water Company.

Mr. S. H. MacKenzie. I think if that could be done, perhaps the plan mentioned by Mr. Hawley would be effectual. Our commissioners have objected to setting aside in cash the total reserve for depreciation, because during a period like we have been going through the last four or five years, if we could not have used our reserve fund for new work, but had had to go out and borrow money at an excessive rate, it would have made quite an inroad on our income. We would have received but about four per cent on our reserve and might have had to pay seven or eight per cent. Their contention is that, if the money is invested in the plant and the plant made to earn a sufficient gain to take care of the reserve for depreciation, they were carrying out the right principle. There should be no trouble in renewing our bonds if our plant has earned all expenses, including depreciation; whether the depreciation is in cash or actual new construction, it will cost more to finance new construction a few hundred dollars at a time, than to renew an issue of bonds of a large amount with an efficient plant back of them.

President Sherman. Is there further discussion? Are you ready for the motion? (*The question was put and carried.*)

President Sherman. Is there anything further to come before this session of the convention?

Mr. S. H. MacKenzie. I think, as this report has been adopted, that it might be wise for this convention to continue the committee, directing it to place this matter before the public utilities commissions of the New England States for their approval or suggestions, so that we may secure a uniform system for all of these states if possible.

Mr. S. H. MacKenzie. I therefore offer the following motion, viz., that the Committee on Uniform Accounting be hereby continued, and is requested to send a copy of its report of September 9, 1920, — containing the "Classification of Uniform Accounting for Municipal Water Works" this day adopted by resolution of the New England Water Works Association as a standard,—together with a copy of such resolution,—to each of the public service or utilities commissions of the several New England States, and to ask the coöperation of such commissions in the recommended use of the general scheme of such accounting classification. (*The motion was seconded, put, and carried.*)

Mr. A. R. Hathaway * (*by letter*). As a member of the accounting committee I have been much interested in reading the proof of the discussion pertaining to adoption of report and accounting classification submitted in 1920 by the Committee on Uniform Accounting for Municipal Water Works, and have been somewhat surprised and pleased at the absence of vital criticism of the scheme. What little criticism was attempted appears to have been due to a lack of understanding of the report and failure to carefully study the classification offered. Being unable to be

* Water Registrar, Springfield, Mass.

present at the discussion, I am submitting the following as of some possible assistance to a better understanding of the matter.

It should be borne in mind at the outset that the report and classification are not to be considered as a complete text-book of detail (similar to the printed pamphlets of accounting systems prescribed and issued by the various public utility commissions of the country for use by the private utilities), but rather as a *composite outline* of the principal and fundamental accounting results needed to be obtained, as indicated in some of the best of these prescribed systems, and as gathered by a study of the same.

With this in mind, the entire accounting scheme can be more easily and simply followed and understood by *first considering only the three principal statement results* to be accomplished, as shown in *condensed forms* on pages 64, 70, 74 of the report as printed in the JOURNAL for March, 1921; the supporting items suggested for same can then be found *indicated* in the detail pages following each condensed statement form; these supporting items can be used or varied to any extent wanted without affecting the integrity of the scheme, or the results to be obtained (as shown on the three pages above referred to); thus allowing any degree of flexibility in the use of the classification.

It should be impressed upon the officials of the smaller municipal water works, and also upon those who may not be so familiar with accounting, that the seeming mass of subdivisions and subaccounts, partially indicated as supporting the three essentials above referred to, are *not the essentials* themselves, and should not be allowed to confuse their minds at the outset of their consideration of the scheme. In fact, if all the municipal water-works operators could have their accounting officials keep *only the group accounts* shown on page 64 (Income and Profit Loss Condensed Statement Form), they would then obtain the uniform results essential for operating comparisons with each other, and, knowing the total quantity of water supplied, be able to easily show the cost per million gallons furnished, and the proportional percentage of such cost for each of the several group accounts or logical processes of operation.

Likewise the essential results in Assets and Liabilities could be shown in uniform manner by using *only the group accounts* suggested on page 70 for Condensed Balance Sheet Accounts. The Condensed Form for Cash Summary, on page 74, needs no further comment or explanation.

By approaching the matter in this simple but comprehensive way, I cannot see how any one should get the impression of the scheme being elaborate, for it was the purpose of the committee to avoid giving such an impression, as is usually obtained by a *first reading* of the text-book classifications prescribed by the various public utility commissions of the different states for the private utilities, without a further study of such classifications.

One thing that should be kept in mind (which in the discussion was apparently lost sight of at times) is that the submitted classification is

intended primarily for *municipal* water works, as those privately-owned are already operated under uniform accounting requirements of the different state commissions, as elsewhere referred to.

Regarding the matter of depreciation and treatment of same in connection with public utility accounts, there are an increasing number of opinions being handed down by public utility commissions and other authorities, and, while many differing views are expressed as to details, there appears to be practical agreement as to the principal accounting requirements. As I understand the matter such requirements applicable to *municipal utilities* seem to be about as follows: the plant or property assets are carried on the books at the full amount of outlays made, or on a cost basis entirely; proper depreciation charges (on tangible depreciable portions of such assets) are to be included in the operating expenses of each year, being debited to same at regular stated intervals, and thus distributing this burden of certain costs evenly throughout the estimated life of such assets. As such charges to operating expenses each year in effect actually reduce the otherwise gain or surplus account of that year by the same amount, such reduction, reservation, or appropriation, from the book surplus account (which is a liability account), should be carried as a separate *reserve* or appropriation account (liability, of course), against which all future replacements of such property assets (on original cost basis) should be charged as they occur; by this procedure the original cost of all replaced property units is by that much *restored* or kept in the property assets without disturbance of such assets; the balance left in the liability reserve account will at any time represent the amount of estimated depreciation provided for and not yet replaced or made good in the property assets; and the difference between this balance and the total plant or property assets will then represent the net total of such cost assets which is assumed to have been kept up to date. This difference is not usually shown in the balance sheet, but when wanted can be easily drawn off in statement form.

As to the names or titles of the foregoing accounts, that is largely a matter of choice; the leading authorities appear to prefer "Plant, Property and Equipment" (for municipal utilities), or "Capital Installed" or "Fixed Capital Assets" (for private utilities), as the asset account for plant cost or investment; for the charges (debits) to operating expenses to take care of replacements, etc., "Depreciation," "Depreciation and Contingencies," "Depreciation Reserve Charge," etc.; for the appropriation or reserve account (liability) to show how much must be provided for future replacements, etc., "Depreciation Reserve," "Reserve for Depreciation," "Accrued Depreciation or Amortization," "Reserves," etc.

I am glad that in the discussion there was presented the matter of public utilities setting aside from revenues an actual *cash fund* to provide for payment of replacements, etc., due to depreciation. While this has not been a general requirement of public utilities (either private or municipal)

by all accounting authorities, it has lately been prescribed by a few of the utility commissions for private utilities, and is becoming more of an important element in rate cases, with an increasing trend in favor of adoption of such a requirement. As was stated in the discussion, if a sufficient gain resulted from operation it has been a question whether the asset value of such gain as should be reserved for depreciation replacements should be expressed in cash or in property. In either case the asset value is there, provided (as stated) that the utility is a self-supporting enterprise and is operated to produce the profit needed. Otherwise, either the revenues should be increased or the expenses diminished; and one great advantage in requiring an actual cash fund for this purpose is the absolute assurance that the utility is regularly reserving such security against the days certain to come.

On the other hand, the absence of such a cash fund need not necessarily mean that a municipal utility is not providing through its other assets such reasonable security as is practicable under its operating conditions. This is the way the matter appears to me at present, but I am in favor of having such a fund established if possible, and have so recommended to our Springfield Water Commissioners in my last annual report.

As stated in the discussion, ample provision is made in the accounting committee's classification for showing such a fund if wanted, under "XXIV. —Cash (Special Funds),"—or subdivision of same,—as found on page 70 of the report. Where such a fund is prescribed by some of state utility commissions, its temporary use for extensions and certain other purposes is to be allowed, provided such use is treated as a *loan* and repayment is made to the fund within a stated time limit. Interesting and valuable opinions upon this entire subject are being handed down by various public utility commissions throughout the country. As the space herein forbids quoting such opinions, a reading of the same is recommended to those having access to the "Public Utilities Reports, Annotated," especially the opinions found in the following references, viz.:—Arizona—P. U. R., 1920D (p. 613); California—P. U. R., 1920B (pp. 118, 119, 120, pp. 810, 811, 812); Idaho—P. U. R., 1915F (p. 445); Indiana—P. U. R., 1918F (pp. 329, 330, 331); P. U. R., 1920D (pp. 123–124), and P. U. R., 1920C (p. 280); Missouri—P. U. R., 1915C (p. 1017); Nebraska—P. U. R., 1920C (p. 505); Nevada—P. U. R., 1920F (p. 769); New York—P. U. R., 1920D (p. 274); Oregon—P. U. R., 1915D (pp. 855–909); Washington—P. U. R., 1920F (p. 956); Wisconsin—P. U. R., 1920A (pp. 362–394), and P. U. R., 1920D (pp. 434–435).

THE SIGNIFICANCE OF "HYDROGEN-ION CONCENTRATION" IN WATER PURIFICATION.

BY HARRISON P. EDDY.*

[*Read September 15, 1921.*]

The term *hydrogen-ion concentration*, for short written also "H-ions" and "PH," may with sufficient accuracy for popular purposes be paraphrased *concentration of acidity or alkalinity*, as the case may be. Pure water is neutral, — that is, neither acid nor alkaline; and its hydrogen-ion concentration is taken at 7. Acidity is designated by numbers below, and alkalinity by those above 7.

The acidity or alkalinity of a liquid has thus far generally been reported in terms of total quantity of acid or alkali present. It has commonly been determined in water by adding acid or alkali, of known strength, in sufficient quantity to neutralize the original acidity or alkalinity, the neutral point being indicated by a change in color due to a small quantity of organic dye previously added. But the action of the acid is not due solely to its total quantity but rather to its effective quantity or intensity. The essential difference between this old determination and the new hydrogen-ion method is that the latter shows the intensity, or true acidity, rather than the total quantity of acid.

The function of alum used in the process of water purification is to produce a coagulum, or floc, of relatively large size, capable of absorbing or enclosing the finely divided foreign substances which cannot be removed by practicable periods of sedimentation or by filtration at high rates. When absorbed by the alum floc, however, they may be removed readily by sedimentation or by filtration, or by both processes jointly. It is obviously important that the alum introduced into the water be converted into floc as completely as possible.

It has generally been supposed that the precipitation of the sulphate of alumina is dependent primarily upon the presence in the water of sufficient alkali, and that any excess of alkali likely to be present in waters generally used as sources of water supply is not disadvantageous. However, certain experiments indicate that there is an optimum point at which apparently all of the aluminum is thrown out of solution, but that above that point on the side of alkalinity or below it on the side of acidity precipitation is not complete. This offers a plausible explanation of the presence in the water being treated of aluminum both in insoluble and soluble form at the same time and of the frequent occurrence of dissolved

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aluminum in filtered waters. It certainly indicates that it may be highly important, if practicable, to carry out the coagulation process at the optimum point of alkalinity, — the isoelectric point. Without this determination, or its equivalent, it is impossible to know whether the water has the proper PH. It may be too low or too high for complete precipitation and it will probably only occasionally be just at the optimum point.

The presence of aluminum in two forms is explained by some according to the theory that the alum assumes a colloidal condition, by which is meant a condition intermediate between solution on the one hand and suspension on the other. Thus we may speak of salt dissolved in water, as a solution, and sand or fine silt suspended in water, as a suspension. The soap in soapy water may be taken as a popular illustration of the intermediate condition — that is, the soap is a colloid. Some substances, like the alum used in purifying water, may be in, or be changed into, any one of these three conditions. The change is one of condition rather than of composition.

Another theory is that the alum may exist as different chemical compounds, some of which are soluble and others insoluble.

Whichever of these theories may be accepted, the important point is that the alum can be converted completely into insoluble aluminum hydrate only within a narrow range of hydrogen-ion concentration, which is not indicated by the methods commonly used for determining alkalinity, and that either above or below this zone the aluminum, or a portion of it, may be present in solution.

It follows, therefore, that it is as important to reduce an alkalinity which is too high as to increase an alkalinity which is too low. This introduces a step in the process of the treatment of water which is not common and which may prove of material value.

It is hardly necessary to point out the fact that the hydrogen-ion concentration appertains to the condition of the water for satisfactory coagulation and is not a method for determining the quantity of coagulant required. This must be done as an entirely independent step in the process.

For ascertaining the isoelectric point the determination of the hydrogen-ions affords a convenient and practical means. This may be accomplished in a manner similar to that long used for the determination of the total quantity of acid or alkali present. Thus, by the use of several indicators constituting virtually a scale of indicators and by the addition of the proper quantity of alkali, or other compound, it is possible to bring the water to the exact hydrogen-ion concentration required for complete precipitation of the aluminum from the alum added to the water. Theoretically, this may be so minutely controlled in practice as to prevent the occurrence of dissolved aluminum in the presence of the insoluble aluminum floc.

As the difference in electrical pressure or potential between any metal and its ions varies with the concentration of those ions, it is possible to

determine this concentration by means of suitable electrical apparatus, one form of which is known as the "potentiometer." By the use of the hydrogen electrode,* therefore, it is possible to determine the concentration of the hydrogen-ions.

In order to take advantage of the hydrogen-ion concentration in the operation of a water purification plant, it will be necessary to control the chemical treatment according to several steps, such as —

1. Determine the quantity of alum required for successful treatment under conditions prevalent at the time.
2. Determine the PH of the water to be treated.
3. Determine the quantities and kinds of chemicals to be introduced, in order to bring the water to the isoelectric point for coagulation of the aluminum.

The procedure, then, would consist of adding the proper kinds and quantities of chemicals to produce the isoelectric point and the required quantity of alum for the successful treatment of the water.

The quality of most raw waters varies from time to time, — often materially within very short periods of time. This variation may be in bacterial content, organic matter, numbers of micro-organisms, turbidity, temperature, or in all of these. It is obvious, therefore, that the quantity of alum must be varied to meet the conditions at the time. It is highly probable, also, that the PH varies greatly and that the kinds and quantities of chemicals used to produce the isoelectric point must be varied accordingly. Even if the PH of the raw water remained constant, the necessary changes in the quantity of alum introduced would make it necessary to vary the chemicals required for producing the isoelectric point, as this condition must be fixed with reference to the quantity of alum used; or, in other words, if coagulation is to be complete the water must be at the isoelectric point after the sulphate of alumina has been added.

It has been suggested that the PH of the water may be determined and the application of the conditioning chemicals regulated automatically by electrical apparatus. Such equipment would greatly simplify the control of the process.

Among the advantages which may possibly result from PH control of water purification plants may be mentioned the following:

1. Prevention of passage of alum through filters and after-precipitation in mains.

The passage of alum either in solution or as a colloid through water filters has long been recognized as one of the defects of the alum treatment. Such water is not satisfactory for domestic consumption and is objectionable for certain industrial uses, such as dyeing. It may be possible by chemical treatment to so adjust the PH as to secure complete precipitation of the alum and prevent its passage through the filters.

* Because metallic hydrogen cannot be obtained, an electrode is used which is covered with spongy platinum saturated with hydrogen.

2. Prevention of corrosive action.

It is possible that the treatment of the water to secure the isoelectric point will reduce the danger of corrosive action by the filtered water, due either to the presence of dissolved aluminum sulphate or to excessive carbon dioxide. The treatment required to produce the isoelectric point in some cases (where acid is required) might not reduce — in fact, it might actually increase — the amount of free carbonic acid present in the water. It does not follow, therefore, that in all cases advantage can be taken of reduction of both of these corrosive substances, although it may be possible to so adjust this treatment as to accomplish this. It is conceivable and has been suggested, however, that in practice water treated in this manner might become more highly corrosive than that treated in the ordinary way.

3. Control of small plant and animal life.

It has long been known that the growth of microscopic organisms and bacteria is favored by the concentration of acidity, within certain limits, outside of which there is an inhibiting effect. It has been suggested that by securing the optimum PH for precipitation of alum, the environment of such organisms may be so changed as to prove detrimental to them and inhibit their growth. There is scarcely any definite information on this point and it is included herein merely as a suggestion of possible means of controlling growths in filter plants, which in some cases have been quite troublesome.

4. Possible reduction in size of filter plant.

It is a matter of common knowledge among chemists that precipitates formed under certain conditions settle and filter much more readily than those formed under other conditions. There seems to be ground for the belief that alum precipitated at the optimum PH point may form a floc which will settle more readily and permit of more rapid filtration than similar floc formed at a less favorable PH. Should it prove that coagulation at the isoelectric point will produce a floc which will coagulate and settle more readily and permit of a higher rate of filtration, a corresponding reduction in size of coagulation basins and filters might prove a substantial advantage. While it is conceivable that the change in the character of floc, due to PH control, might warrant a change in the depth of filtering material or in some other detail of construction, this does not appear at all probable.

5. Possible increase in efficiency of operation.

If coagulation at the isoelectric point will result in the formation of a better floc and in avoiding the passage of dissolved aluminum through the filters, it may be that the bacterial efficiency of filtration will be improved to some extent. It seems reasonable to expect such a result from observation of the process of coagulation.

While these and perhaps a number of other advantages of the PH control may be possible from a theoretical point of view or may be obtained in the laboratory, it is important to prove to what extent, if any, they can be secured in the practical operation of water purification plants.

There is little doubt that the determination of the hydrogen-ion concentration will permit of a more intelligent study of the water and the reactions taking place during its treatment. This fact alone is sufficient to warrant making a thorough investigation of the subject and determining the PH value in many cases.

It is possible that the methods of control now in use, based in part upon the older conceptions of the chemistry involved and in part upon practical operating experience, permit of as close operation of purification plants as it is possible to obtain, even with the assistance of the more delicate and refined hydrogen-ion determinations made in accordance with the latest theories of chemistry.

It often happens that empirical methods lead to practical results which are as satisfactory and effective as those based upon more accurate knowledge. This fact, however, does not justify disregard of progress in science and of new theories. It cannot be gainsaid that the older practitioners in any profession, or in the arts, are inclined to adhere to the older methods and processes as a result of their familiarity and experience with them and a natural reluctance to adopt new ideas. The older members of the profession should constantly guard against this tendency, in order that valuable improvements may not be ignored, simply because they involve new discoveries and new theories.

While it is wise to give proper weight to the reasonable doubt of success in order not to be misled by theoretical considerations, it is certain that the subjects of coagulation and filtration should be very thoroughly studied in the light of the more modern chemical theories. Such investigations will lead to a better understanding of the chemistry of coagulation than that which has governed this important subject in the past. With improved conception of the process, advantages of more or less importance are likely to follow. The true value of the hydrogen-ion determination can only be learned through investigations covering a great variety of conditions encountered at a large number of plants.

Such investigations may well lead to a re-study of the whole subject of chemical treatment of water, and improvements may result in lines entirely apart from the hydrogen-ion determination, which furnished the initial incentive for such further study.

Discussion.

Mr. Harry W. Clark.* I believe that we all can study this matter, and I think quite a few of us will know more about it in a year or two than we do now. It is a very delicate method, and a rather scientific and involved method, covering water filtration, but I have no doubt something will be worked out along practical lines, started by this method. We certainly ought to know more about the methods by which we get the best purification. We all of us have many difficulties. We have found alum coming through, alum in solution, and so forth. If this is going to lead us out of our difficulties it certainly is a great advance. Mr. Eddy has covered about everything that we know at the present time.

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MR. FRANK W. GREEN.* The heaviest floc is not always the most desirable, because at times a very heavy floc is apt to break up on its way to the filters on account of being less cohesive than a lighter floc. This breaking up of the floc may allow the passage of some of the aluminum hydroxide through the filter beds. We are making a number of studies covering the PH value and the more important mineral constituents, to determine their relation to the character of the floc.

One of the controlling factors of coagulation is the carbonic acid. The simplest way of getting ri l of carbonic acid is aëration. Formerly we tried to get rid of all the carbonic acid, but it appears probable that at times we will get better results by removing only a portion of it.

The impression that I got from Mr. Eddy's paper was that the isoelectric point was identical with PH-7, or the neutrality point. This is far from being the case. The isoelectric point in certain acids may be as low as PH-3, which is a thousand times PH-7. I have in mind a water having an alkalinity of 45. The PH value of this water is less than the isoelectric point, and lime must be added to get it to the proper point for coagulation.

I have here some notes on hydrogen-ion concentration which present a different view of the same subject:

The actual determination of the PH value of a given water is one of the most simple tests that the water analyst has to perform, provided he takes advantage of the permanent standards and indicator solutions now on the market. The test consists in adding a few drops of the indicator to the water sample, and comparing its color to that of the standards. What could be more simple! This is the colorimetric procedure which has been developed to its present state of perfection and simplicity by the scientist.

The study of the theoretical side of hydrogen-ion concentration is very complex and difficult, and should be undertaken only by one possessed of a thorough knowledge of dye-structure, spectroscopy, physiological optics, and electrolytic dissociation. For instance, in deciding on a method for the colorimetric determination of the PH values of a certain zone, many indicators must be examined and their various advantages and limitations compared. Numerous electrometric experiments of extreme delicacy must be patiently performed.

However, after the proper formulas have been worked out, solutions of definite values can be readily duplicated by any one who has the requisite technique, even though he may have absolutely no theoretical knowledge of the subject. These solutions can be used by any one who is not color blind and can count to ten.

Hydrogen-ion determination, as applied to natural waters, is the measurement of the minute amount of hydrogen which is present in the

*Superintendent, Filtration, Montclair, N. J., Water Company.

ionic state due to electrolytic dissociation. Pure water has a value of PH = 7.0, but natural waters may vary from 6.0 to 8.0 (1 part to .01 part per billion). Although present in almost inconceivably small quantities, its determination is of considerable value because coagulation, corrosion, and other important reactions take place in definite zones of hydrogen-ion concentration. The result obtained for any given water depends upon the proportions of the contained amounts of certain acids and bases, those of greatest influence in normal supplies of this region being the free carbonic acid and the bicarbonates. So important are these two constituents that $3\ CO_2$ divided by HCO_3 will give a rough approximation of the H-ion concentration.

Although intimately related to the acidity and alkalinity, the following shows that it is a separate and distinct feature governed by rules peculiar to itself:

"A liter of normal acid becomes fifth normal if we dilute it five times. . . . If we were to add to 1 liter of perfectly pure water of PH = 7.0, 1 cc. of N 100 HCl the resulting solution would be about PH = 5.0. . . . If, on the other hand, we were to add this same amount of acid to a liter of standard beef infusion medium of PH = 7.0, the resulting change in PH would be hardly appreciable." (W. M. Clark.)

The acidity varies proportionately, or nearly so, in all cases to the amount of HCl present; the PH value becomes one hundred times as large in the first instance where no salts are present, and changes scarcely at all where there is a "buffer" present. This inhibition of PH change is called "buffer action," and is of importance in several water-supply problems.

The pioneer investigators of the early '90's, for reasons of their own, chose to express their results in terms of the logarithm of the reciprocal of the grams of ions present in one liter. This term is now known as the PH value. For general theoretical work where there is a wide field to be considered, say from PH = 2.0 (which is the hundredth of a gram) to PH = 11 (which is the hundred billionth part), it is undoubtedly of considerable convenience. For our work which lies in the zone PH 6.0 to 8.0 (1.000 to .010 p.p.b.), it would appear that direct readings in parts per BILLION would be more readily comprehended by the practical water-works man. Also it would bring out more clearly that PH = 7.0 is ten times greater than PH = 8.0; which fact in itself is somewhat confusing to the non-mathematical mind. This term might be named the HB value, to show its relation to the PH values which have become accepted and will probably be retained in purely scientific investigations.

The following table gives the zone of concentrations commonly encountered in water supply investigations and routine analyses. Column A gives the PH value and Column B gives the HB value which is also the $H+$ equivalent in parts per billion, or, mathematically $(H+)^{-9}$ or $(1\ H+)^{9}$.

(A) PH Values or (Log 1/H_+).	(B) H-ions (Hb) p.p. bil.	(A) PH Values or (Log 1/H_+).	(B) (Hb) or H-ions p.p. bil.
6.0	1.000	7.0	.100
6.2	.630	7.2	.063
6.4	.400	7.4	.040
6.6	.250	7.6	.025
6.8	.160	7.8	.016
7.0	.100	8.0	.010

For routine work, quite accurate results may be obtained by the use of the sets of Brom thymol blue standards with a range 6.0 – 7.6 and phenol red series of 6.6 – 8.2 in sealed test-tubes. Bottles of solutions of the two indicators, and color charts to insure that the standards are correct, can also be purchased for a small amount. Take 10 cc. of the water to be tested, add a few drops of the indicator, and compare with the permanent standards. Each one of us should familiarize himself with at least the broader aspects of this fascinating subject, and those who can do so should add to the data that is being collected for further study and interpretation.

MR. STEPHEN DEM. GAGE.* The question of the hydrogen-ion concentration of water is so new as a practical water-works proposition that I have had little opportunity to look into it. After listening to Mr. Eddy's very clear exposition of its possibilities, especially in connection with filtration and corrosion, it has come to me that perhaps a study of the hydrogen-ion concentration may point the way to a solution of a problem which has been bothering us for some time.

We have had trouble in the operation of one of our rapid sand filter plants practically ever since it was started, some ten years ago. In the summer we could get good coagulation using alum and soda, and make good water. In the winter, however, it has been very difficult to get a floc which we could hold on the filters. After two or three hours, the beds seem to become porous and the color and turbidity of the effluent would rise rapidly. The only way the filter operator can make good water at such times is to take frequent color readings on the effluent and wash a filter as soon as the color begins to come through. We have tried everything we could think of to overcome this difficulty, but so far we have failed to solve the problem satisfactorily, but we have always believed that the trouble was due to some peculiarity in the water which we were trying to treat. When this condition occurs again, as it is sure to occur about the first of December, we are going to try to work it out along the lines of this new theory, and hope this will prove the solution for which we have been looking.

MR. EDDY. I want to thank Mr. Green for calling attention to that apparent error. I did not intend to give the impression that the isoelectric point is coincident with 7. In some of the work we have been doing the

*Chemist and Sanitary Engineer, R. I. State Board of Health.

isoelectric point is about 3.5. The isoelectric point varies with the material which is to be coagulated and precipitated.

Another interesting fact with reference to some materials is the so-called "drift." In the material to which I have just referred, which appears to coagulate best at a PH of about 3.5, which is obtained by adding sulphuric acid, there is a rapid drift, so that in the course of an hour or two the material has drifted back from 3.5, or thereabouts, to a point perhaps as high as 6. At this PH, the material acts in a very different manner from that at a PH of 3.5. It is possible to overcome this difficulty, in a measure, at least, by treating the material with an excess of acid, to bring the PH below the isoelectric point, so that the liquid will not drift back far beyond the point most advantageous for handling the colloids within the time available.

Another rather interesting experience has been with the potentiometer, by means of which the PH value can generally be determined electrically. In certain tannery liquids, it has been found that the hydrogen electrode is very quickly "poisoned," so that it becomes absolutely useless. The color indicators, however, appear to give correct results. They agree with those obtained by the potentiometer, provided it is manipulated with sufficient rapidity to secure the results before the electrode becomes "poisoned." While the potentiometer is not adapted for practical use in that liquid, there does not appear to be any reason why it would not be practicable for waters used as sources of domestic supply. It is, however, a very delicate instrument, and, as now constructed, it appears to be better adapted for laboratory research than for field investigations.

A promising use for the hydrogen-ion control in the purification of water is in the industries where a high degree of purity or the absence of certain chemical compounds is necessary, such as in dyeing. In one such plant which has come under my observation, there were occasional difficulties in dyeing, for which the only explanation seemed to lie in the quality of the water used, notwithstanding the fact that the water was so purified that it did not cause such difficulties during a large proportion of the time. It may well be that more complete control of the hydrogen-ion concentration would provide a water so purified as to be satisfactory for the dyeing process at all times.

REPORT OF THE COMMITTEE ON STANDARD SPECIFICATIONS FOR WATER METERS.

Discussion.

(Past President Samuel E. Killam takes the chair.)

Mr. Charles W. Sherman. Mr. President, I assume it is not necessary to go to any extended discussion in presenting this report. It was printed in the June issue of the Journal, page 187, and represents a very considerable amount of work on the part of a joint committee, consisting of a committee appointed by this Association and one appointed by the American Association. Perhaps I may take a minute to briefly review the appointment and work of the committees without reading the specifications.

Mr. Robert J. Thomas presented a brief paper at our convention in Portland, in 1916, calling attention to the desirability of uniform standard specifications for meters, and as a result of his paper a committee was appointed by our Association. In 1919 the American Association voted to establish a similar committee, which was done at once, with our past president, Mr. Saville, as its chairman. Our committee had not done much work prior to that time, although some correspondence had been had, but war conditions prevailed nearly the whole period prior to 1919 and made it seem impracticable to accomplish any real results, and of course all of us were extremely busy.

In 1919, however, the time seemed ripe to really do something, and a joint meeting of the two committees was called, which was attended by substantially the whole membership, and at that meeting I was chosen as chairman of the joint committee and it was decided that the two committees should work jointly as a single committee. Mr. Brush, who is chairman of our own committee, acted as a representative of the committees in the sessions of the Meter Manufacturers Association, which was discussing the same thing, and which drafted for our consideration suggested specifications, which of course were discussed in Mr. Brush's presence and worked out in preliminary form before they came before our joint committee. We discussed them in considerable detail, and they went back to the manufacturers and were revised and sent to us again and were adopted in, I think, a form which was acceptable to every member of the committee, and, as far as I am informed, thoroughly acceptable to the manufacturers.

The specifications have been made as simple and general as it seems possible to make them, and still we think are explicit on the points of prime importance. They cover only disk meters, and therefore are not a complete performance of the duty entrusted to the committee. We hope that we

shall be able to complete the work by passing on specifications for the current type of meter and compound meters eventually; but it seemed to the joint committee wiser to get a disk meter specification adopted and tried out at least for a brief period, before recommending other specifications covering other types.

The specifications, as most of you know, were presented to the American Association at its convention this year, and were adopted without modification. The American has but its one meeting a year, which is the convention, at which such action can properly be taken, and, as you know, theirs came earlier than ours.

The specifications are now submitted to this Association for action, and I believe that the Association is fully warranted in accepting them as they stand.

Mr. J. M. Diven. I understand that the committee has discussed this very thoroughly and taken it up with the manufacturers, and that their specifications are practical. Their report is so complete and so conclusive that there does not seem to be any room for discussion.

Mr. George A. King.* I do not think that the specifications quite cover one point. I should like to see a clock on a five-eighths meter, the maximum reading on which was only 10 000 instead of 100 000. Those who read their meters frequently would find that a desirable feature. Probably those who do not read them frequently would want one whose maximum reading was 100 000, as the report calls for.

Mr. R. K. Blanchard.† *Mr. Chairman and Members,* — The Manufacturers' Committee was appointed at the request of your Association. We spent a great deal of time in preparing these specifications, and endeavored in every way to meet the demands of the water-works superintendents and the operators. We changed many things in the construction of the meters, which made all the different manufacturers change something to have a uniform specification. The specification as it stands to-day, from the manufacturers' point of view, is very satisfactory.

I think that we do not appreciate how much a real standard specification on water meters means. The manufacturers receive specifications on which to bid on meters, and I venture to say there are not two specifications which are exactly the same, both as to tests of meters and construction, and in this specification your committee has demanded of the manufacturers a meter that will answer all general requirements as to test and construction, and as far as the manufacturers are concerned the specification as it stands is very satisfactory. It protects not only the water-works operators, but also gives the manufacturer a definite goal which he has got to meet; and the manufacturers, I am sure, would be very glad to have this specification adopted. And on that point I hope that we

* Superintendent of Water Works, Taunton, Mass.

† Chief Engineer, Neptune Meter Company.

can in some way get this specification before the members of the New England Water Works Association so that they will use it.

[It was voted that the report of the Committee on Standard Specifications for Water Meters be accepted and adopted, and the committee continued.]

RAINFALL IN NEW ENGLAND.

Corrections in tables published in June, 1921, JOURNAL:

Bloomfield, Vt. Average rainfall should read: July, 4.95; November, 2.26; Annual, 37.85.

Cavendish, Vt. Average rainfall should read: December, 2.75; Annual, 36.49.

Wilmington, Vt. Average rainfall should read: January, 3.28; February, 4.23; March, 4.43; April, 2.12; May, 4.80; June, 4.40; July, 2.44; August, 4.33; September, 4.74; October, 4.42; November, 4.19; December, 4.28; Annual, 47.66.

Ashland, Mass. Average rainfall should read: October, 3.43; December, 3.87.

Bedford, Mass. Average rainfall should read: May, 3.12; July, 3.35.

Danvers, Mass. Average rainfall should read: August, 3.06; September, 3.17; December, 2.92.

Hingham, Mass. (Accord Pond.) Average rainfall should read: January, 3.29; May, 3.74; July, 3.67; September, 6.48.

Leicester, Mass. Average rainfall should read: May, 3.39; Annual, 43.38.

Warren, Mass. Average rainfall should read: April, 3.35; July, 4.65.

Williamsburg, Mass. Average rainfall should read: April, 3.71; July, 3.93; October, 3.27.

AWARD OF DEXTER BRACKETT MEDAL.

Mr. Samuel E. Killam. *Mr. President and Fellow-Members,* — We again meet to honor the memory of Dexter Brackett, whose wise counsel and sound advice were always acceptable to and respected by the members of the New England Water Works Association.

Mr. Brackett was born in 1851, elected a member of this Association in 1885, its president in 1890. His deep interest in the organization continued unabated until his death in 1915.

You will recall the tall, kind-hearted man who made many and valuable contributions to water-works literature, all of which are recorded on the pages of our Journal.

It was my good fortune to serve many years under the direction of this honest and clear-headed engineer.

It is now my pleasure, as chairman of the Committee on Awards, to present the Dexter Brackett Memorial Medal for the most meritorious paper published in the Journal for the year 1920.

It is needless for me to say to you who have studied this volume of the Journal, that it was by no means an easy task for your committee to make its recommendation to the Executive Committee, but, in compliance with Rule 4, under which this award must be made, namely, " The medal shall be awarded for the paper which is judged to be most meritorious, bearing in mind its applicability to general water-works problems," we decided that the paper entitled " Lead Poisoning by Water and Its Prevention " was the best paper published in 1920.

I, therefore, take great pleasure in presenting to Robert Spurr Weston this medal. It is needless for me to say more, as the article speaks for itself of the time, thought, and study required in its compilation.

In the absence of Mr. Weston, I will turn this medal over to the President for safe-keeping. [Handing medal to President Sherman.]

MEMOIR OF CHARLES EDWIN HABERSTROH.

Born in Boston, Mass., February 14, 1849.
Died at Framingham, Mass., September 24, 1921.

Mr. Haberstroh joined the New England Water Works Association January 10, 1900, but was not a frequent attendant at its meetings. He was attached to the Sudbury system of the Boston Water Works as engineer, later coming under the control of the Commonwealth of Massachusetts, from 1874 to 1919, when he was retired. His most fitting eulogy is the resolution passed by the Metropolitan Water and Sewerage Board on his retirement, which we quote in full:

"In the retirement of Charles E. Haberstroh, superintendent of the Sudbury Department, which occurred February 13, 1919, the Board feels that the Commonwealth has lost a capable and faithful servant, who has rendered useful and important service in the construction and maintenance of the Metropolitan Water Works. Mr. Haberstroh was connected with the Water Works Department of the City of Boston for many years prior to the acquisition of the works of the city by the Commonwealth, and had a comprehensive and practical knowledge of the Sudbury Department, of which he was appointed assistant superintendent by the Board at the time of the taking of Boston's water works, in January, 1898. In February, 1907, he was promoted to the superintendency because of his knowledge of the Sudbury Department, and held the position until his retirement. His employment of more than twenty-one years has been characterized by faithful devotion to the work with which he was entrusted and untiring zeal in the discharge of the many and arduous duties devolving upon him.

FREDERIC I. WINSLOW.

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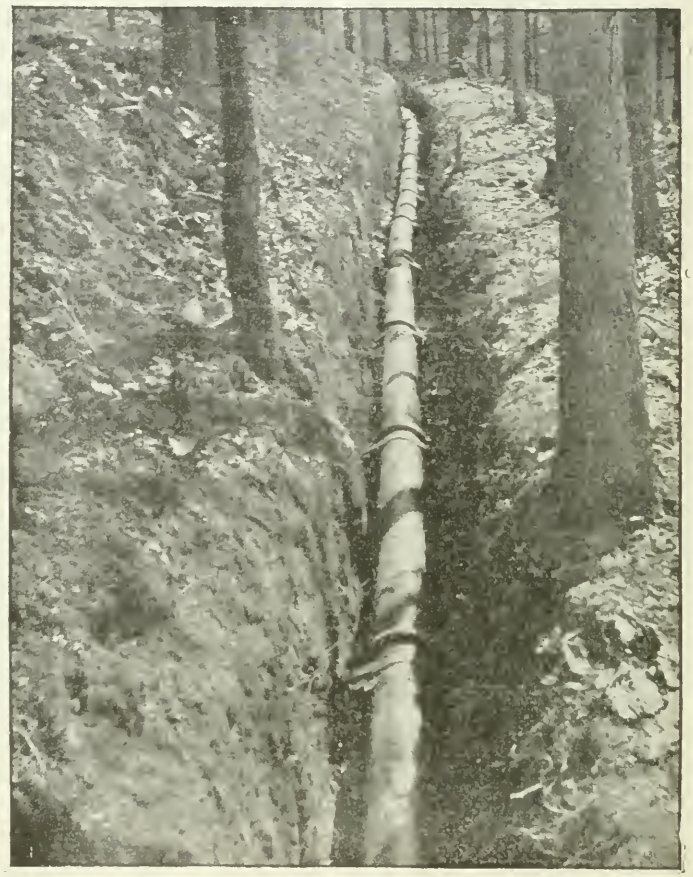

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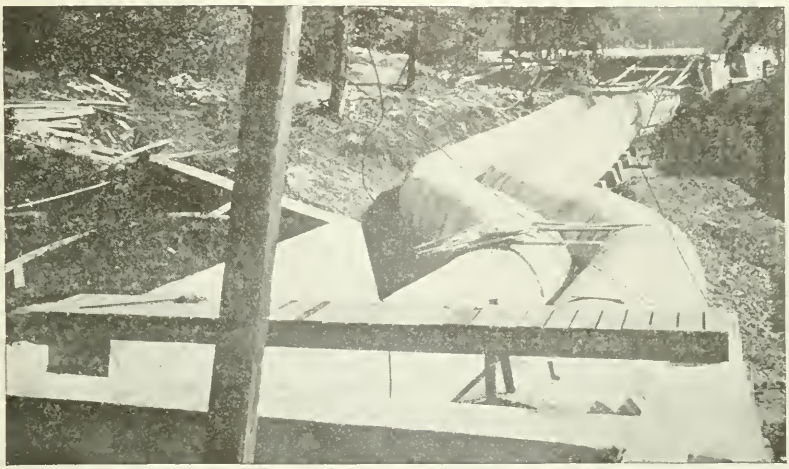

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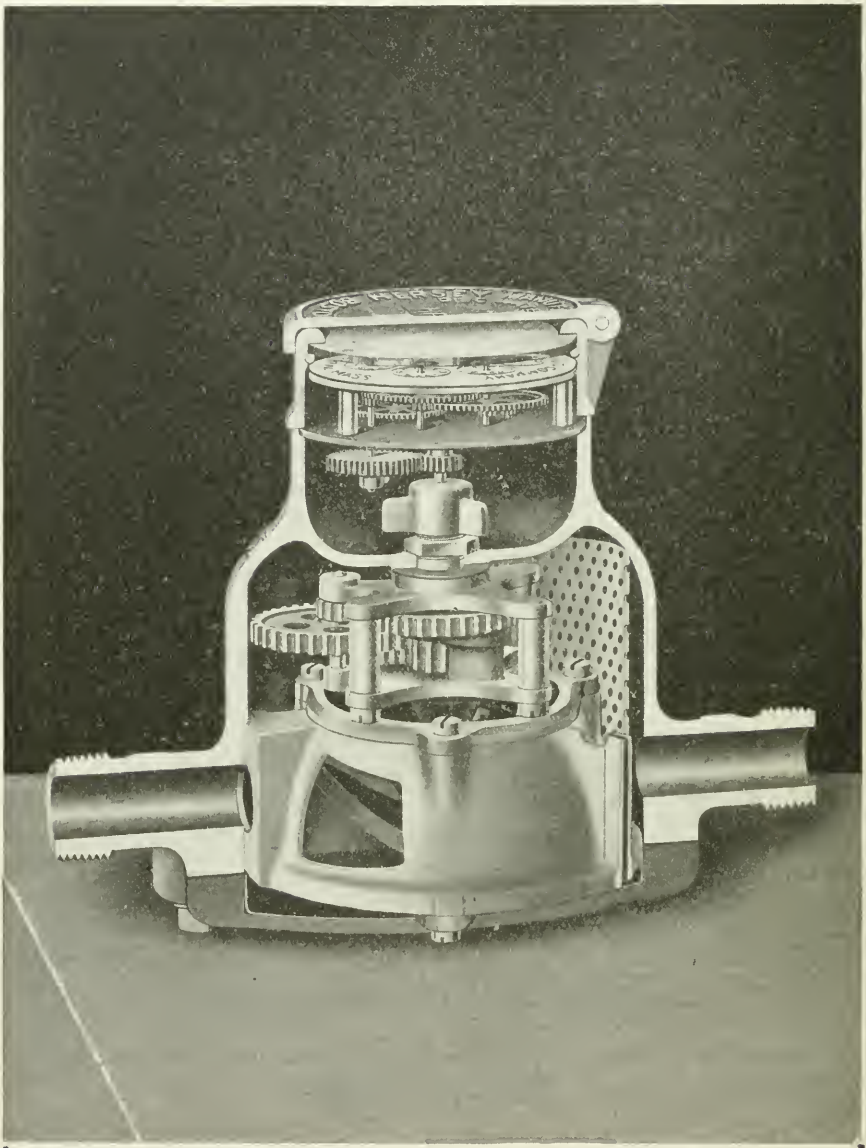

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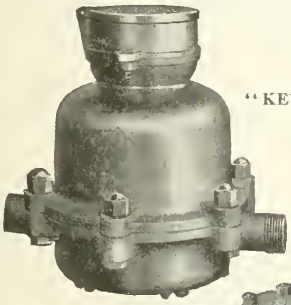

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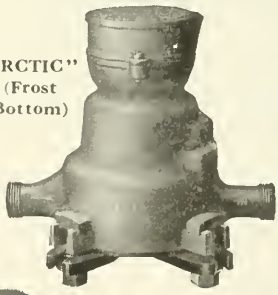

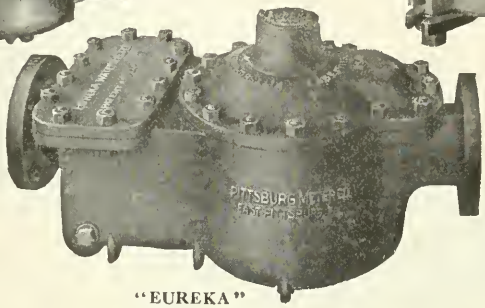

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Water Meters

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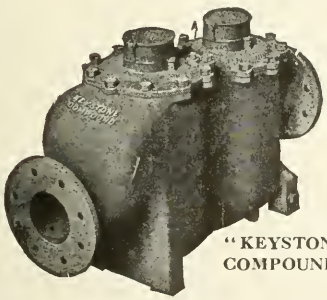
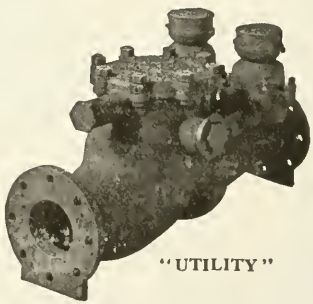
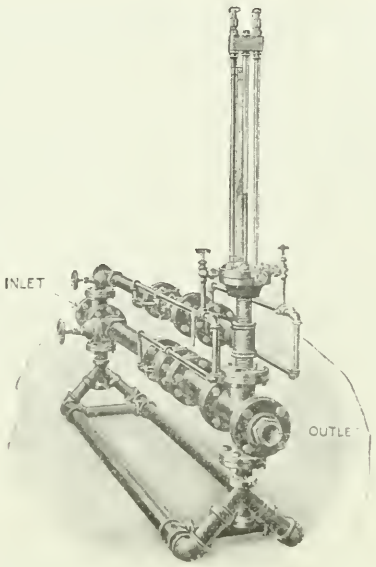


"KEYSTONE-COMPOUND"



"UTILITY"



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A hopeless job, isn't it? Yet many municipalities are even now trying to do what amounts to the same thing,— to fill economically a badly leaking water distribution system. The

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Prevents the possibility of any such hopeless endeavor over an extended period of time, because it indicates quickly, and with convenience, any serious leakage or waste which is occurring in the limited section under test.

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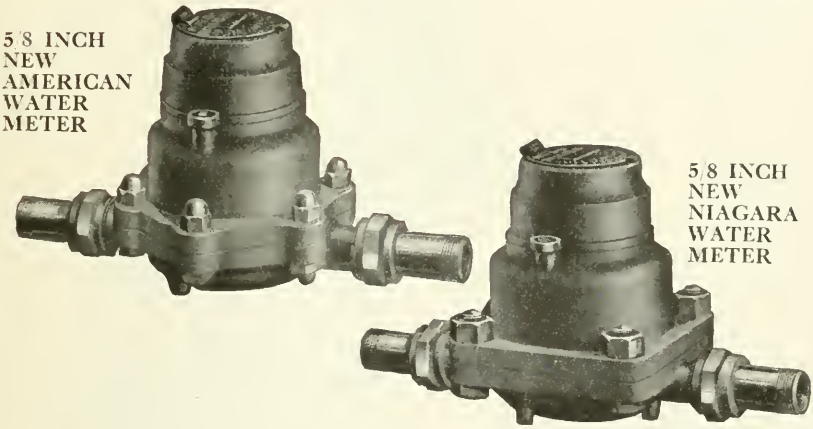
AMERICAN AND NIAGARA WATER METERS

5/8 INCH NEW AMERICAN WATER METER



5/8 INCH NEW NIAGARA WATER METER

Niagara and American Meters are of the disc type. The Niagara Meter has a galvanized cast-iron outside casing; the American Meter has a bronze main casing with either a bronze base or a galvanized cast-iron base. The works in the three different casings are the same and interchangeable. Upon opening the meter at the bolted flange, each intermediate gear may be immediately removed from its bearing, the measuring chamber lifted from its seat, the strainer slipped out, or the register tried by turning the stuffing box gear. All submerged working bearings are protected against sand and sediment. The hard rubber measuring disc is reinforced with a metal plate. Purchaser has option of round reading or straight reading register indicating cubic feet, U. S. gals., imp. gals. or litres.

Round Reading Register

Straight Reading Register

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ESTABLISHED 1892

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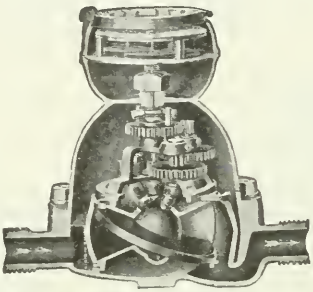

King Model "B" Disc Meter

WATER METERS

cannot be any better than their gear trains, and the life of the gear train is determined by its ability to withstand corrosive conditions.

Hard rubber bushed spindles, intermediate spur gears of hard rubber and phosphor bronze have been a feature of Union Water Meters for forty years. In recent years this has been further perfected by the adoption of Monel Metal for spindles and screws.

The buoyancy of rubber spur gears renders the meter more sensitive and minimizes wear.

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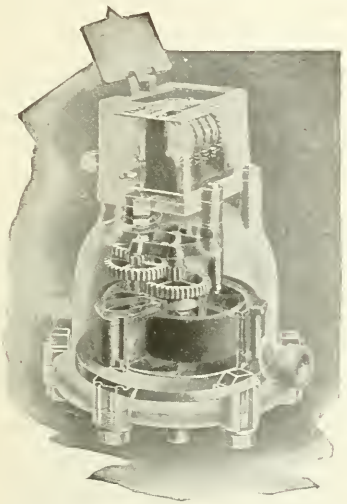
PROVED BY THIRTY YEARS OF SUCCESSFUL SERVICE
UNDER EVERY WORKING CONDITION**



The real value of a meter can only be learned by putting it through a long course of hard work; and it is only by adding the maintenance for all that time to the original price that the true cost is known.

Apply both these tests rigidly to the **EMPIRE,** and you will quickly see why it is

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If you are looking for a meter that lasts; that keeps its close accuracy for years; that isn't always "stopping" and that costs less to maintain than any other, investigate the **EMPIRE.**

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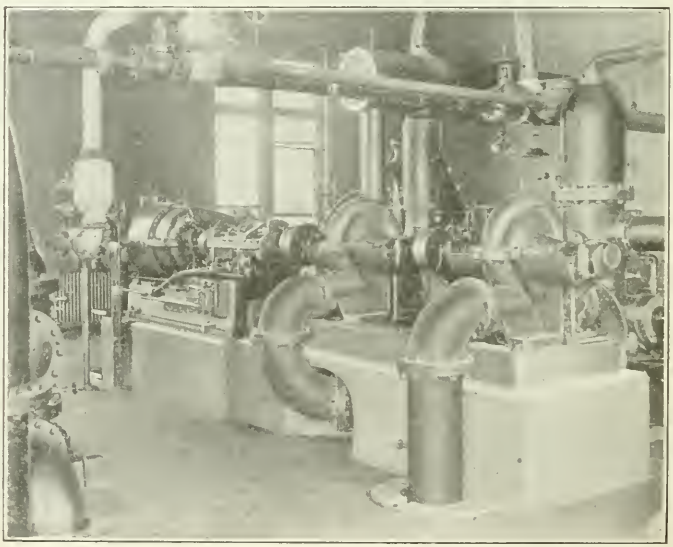

Turbine-driven Pump at the Arlington Station of the Metropolitan Water Works, Boston, Mass.

F. A. Mazzur & Co.
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Complete Water-Works Pumping Plants

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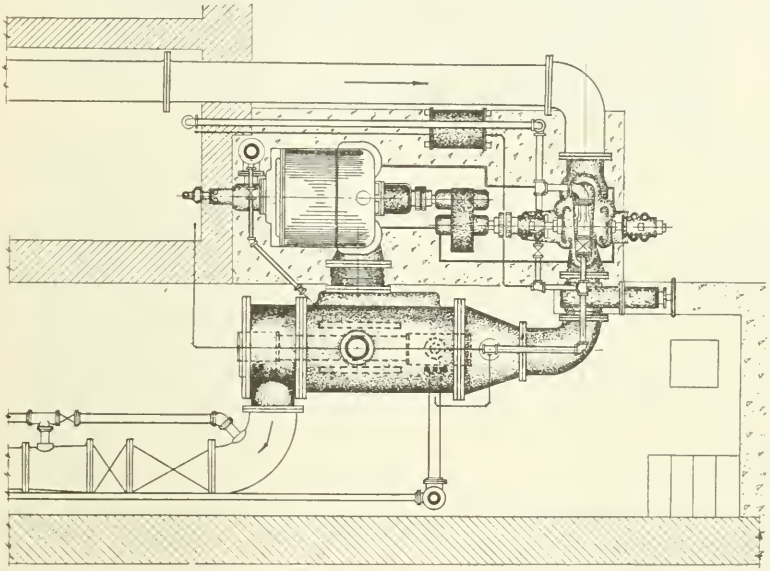

Above illustration shows the general arrangement of a 5 000 000 G.P.D. centrifugal pump for 237 feet dynamic head and driven through reduction gears by a multi-stage Steam Turbine, exhausting into a discharge type water-works Surface Condenser with horizontal air and condensate pump underneath same. Installed by us in the City Water Works, Woburn, Mass., to plans and specifications prepared by H. M. Haven & W. W. Crosby, Engineers, Boston, Mass.

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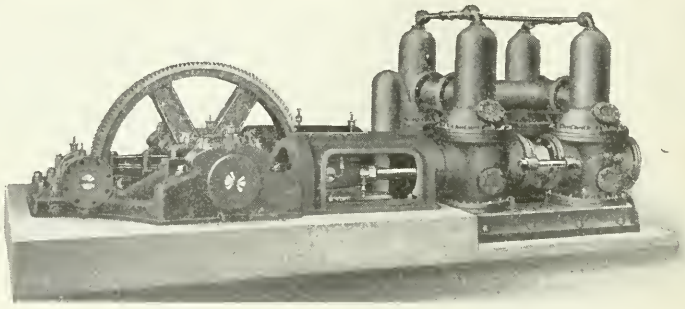

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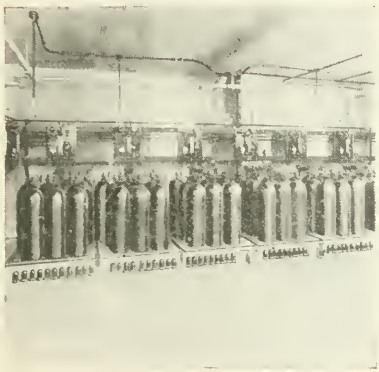

Six of the fifty million live in New York City. W & T Apparatus protects every drop of water supplied to the metropolis. This is one of the W & T installations on New York's water supply.

And by so doing are protected against water-borne disease.

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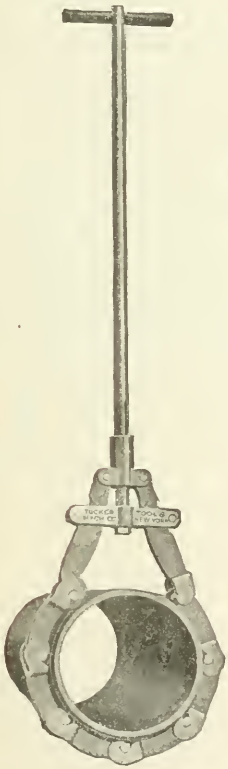

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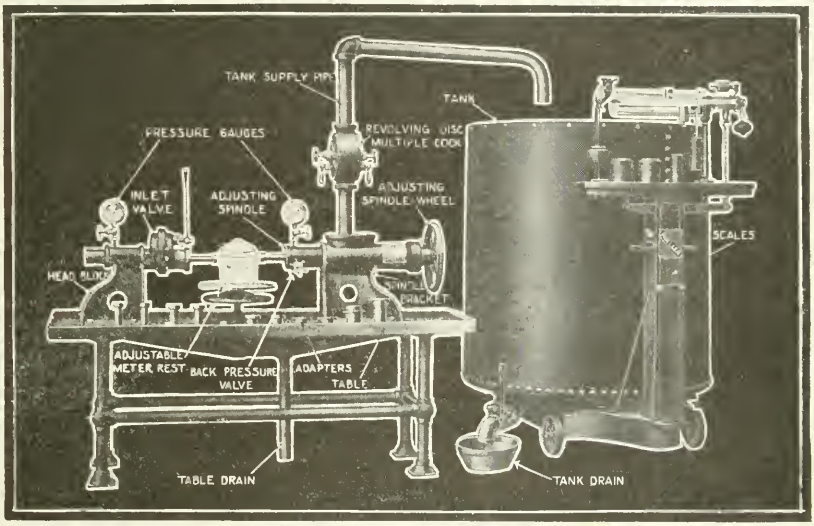

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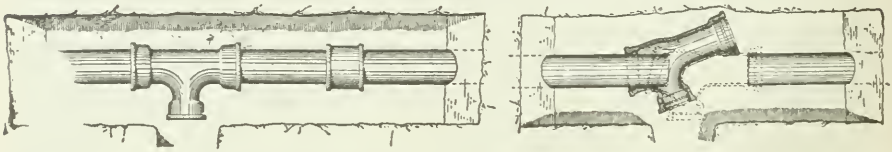

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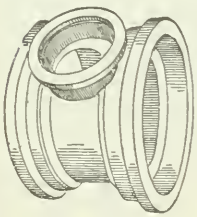

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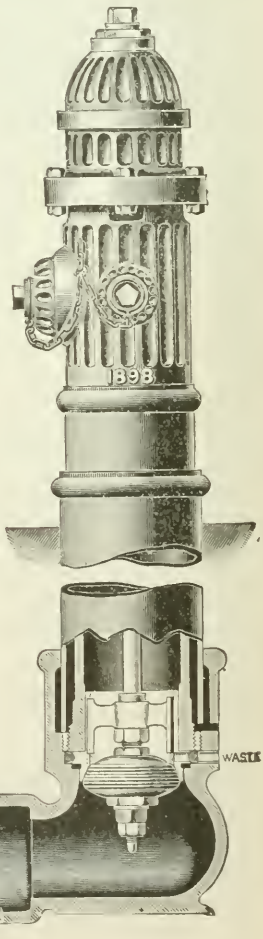

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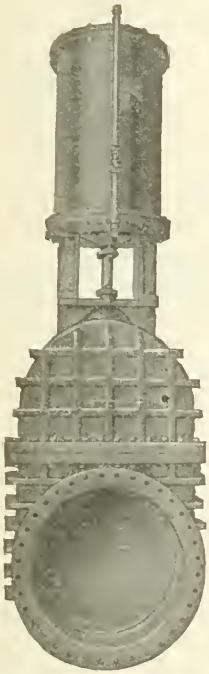

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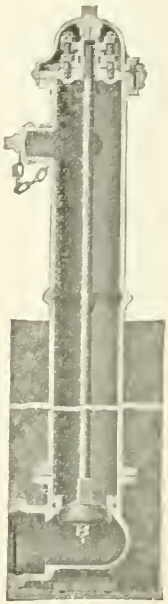

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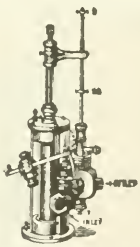

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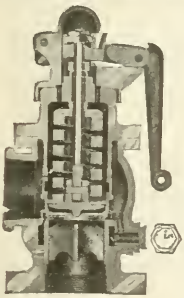

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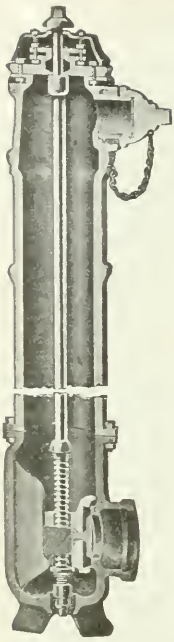

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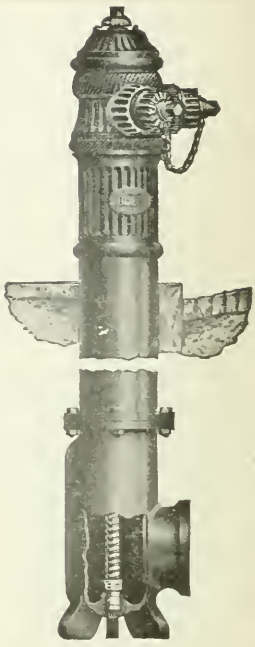

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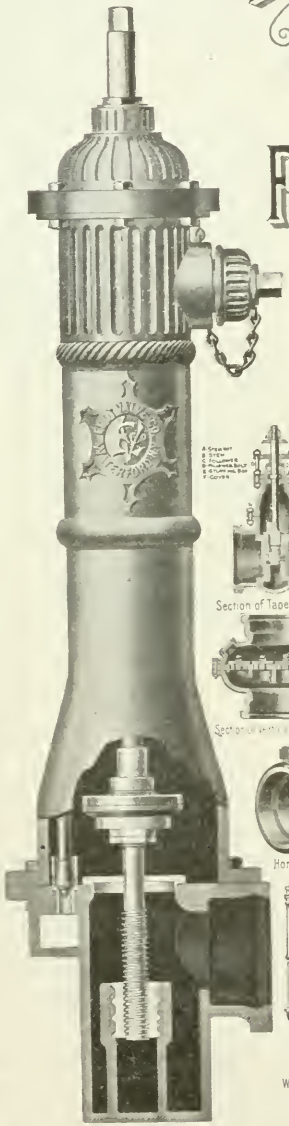
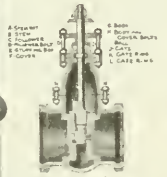
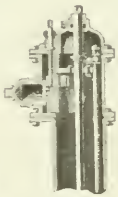
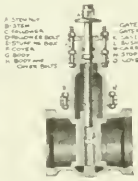




Section of Taper Seat Valve.



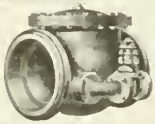
Hydrant with Independent Nozzle Cut-off



Section of Parallel Seat Valve

Section of Vertical Check Valve

Section of Vertical Foot Valve



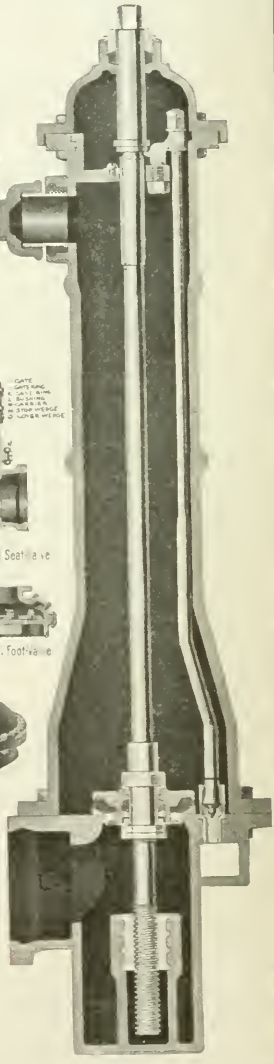
Horizontal Check Valve

Vertical Foot Valve.

Hydrant with Water Crane Attachment.

Indicator Post.

Water Crane with Automatic Drip Valve.



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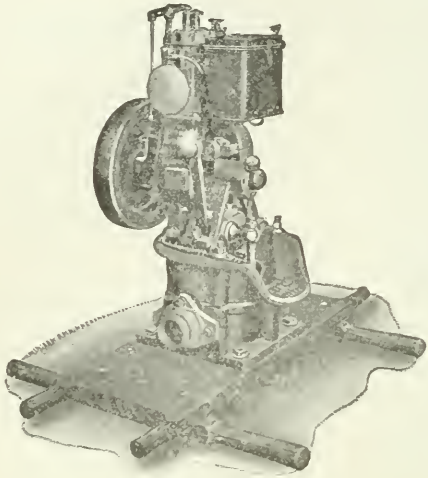

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Twelve Reasons Why

YOU SHOULD USE

Trade **"LEADITE"** Mark

Registered U. S. Patent Office

FOR

Jointing Water Mains

1. **DURABILITY.** Leadite joints increase in strength with age.
2. **NO CAULKING.** Leadite joints require no caulking, because the Leadite adheres to the pipe, making a water-tight bond.
3. **COMPARATIVE QUANTITIES.** One ton of Leadite is equivalent to four tons of lead.
4. **LABOR SAVING.** Saves caulking charges and digging of large bell-holes, and reduces the cost of trench pumping to the minimum.
5. **COST.** Its use saves 50 to 65 per cent. over lead, owing to the saving effected in material and labor.
6. **TOOLS.** As no caulking is required, fewer tools are needed.
7. **TRANSPORTATION.** Considerable freight charges are saved because Leadite is lighter than lead.
8. **HAULING.** Saves hauling expense on the work because you move only one fourth the weight of jointing material.
9. **FUEL.** Saves fuel because you melt only one ton of material instead of four, and not as much heat is required either.
10. **DELIVERY.** We can make prompt shipments.
11. **DAMAGE SUITS.** Claims for damages caused by joints blowing out are prevented because Leadite joints will not blow out under any pressure.
12. **USERS.** Progressive water works all over the country use Leadite.

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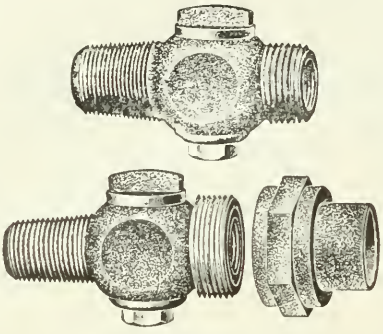

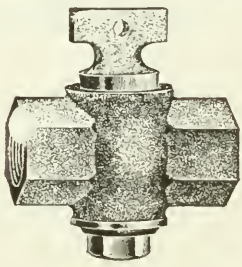

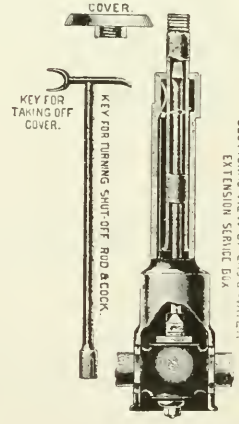

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Vol. 2, No. 2 — December, 1887
No. 3 — March, 1888
Vol. 3, No. 1 — September, 1888

New England Water Works Association

715 Tremont Temple Boston, Mass.

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New England Water Works Association,

ORGANIZED JUNE 12, 1882.

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..... *being desirous of admission into the New England Water Works Association, hereby make application for* .....

(resident, non-resident or associate)

.....*membership.*

I am.....*years of age, and I have been engaged in the following named work:*

I will conform to the requirements of membership if elected.

Signed,.....

Address,.....

Dated,.....*19*

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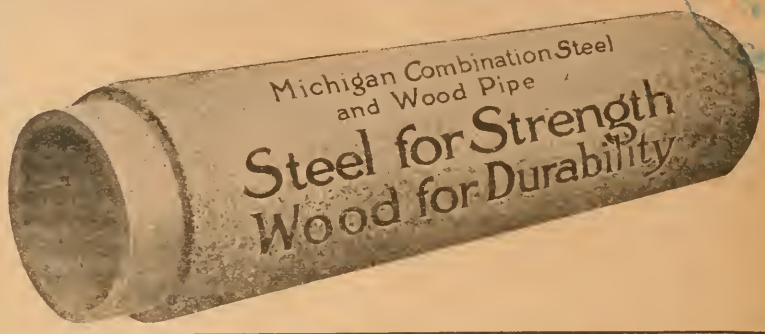

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